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ABSTRACT

This course is one of several subcourses that make up the entire Army correspondence course on wheeled vehicle maintenance. The subcourse is designed to provide the student with information about the operation, malfunction diagnosis, maintenance, and repair of wheeled vehicle clutches, transmissions, and transfer cases. It provides the basic theory, and also includes on-the-job task assignments. The subcourse is divided into six lessions covering the following topics: fundamentals of gears; wheeled vehicle clutches; fundamentals of conventional transmissions and power takeoffs; maintenace of conventional transmissions and power takeoffs; wheeled vehicle automatic transmissions; and transfer cases. Each lesson contains objectives, text, task assignments, and review exercises. Answers for the exercises are provided after the final lesson, along with an examination and application task test. This subcourse is designed for student self-study, but could be used in small group learning situations. (KC)

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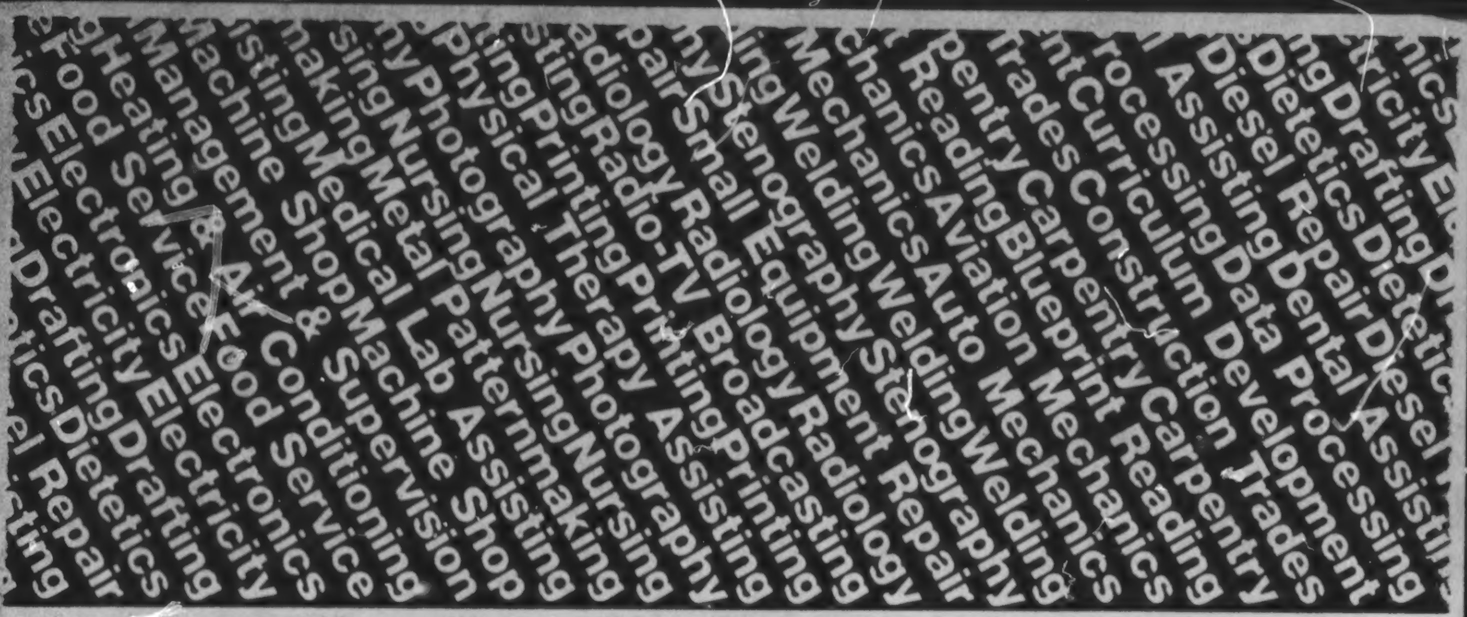

ED212801

CE 031 195

Military Curriculum Materials for Vocational and Technical Education

WHEELED VEHICLE CLUTCHES, TRANSMISSIONS, AND TRANSFERS

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MILITARY CURRICULUM MATERIALS

The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

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- Developing educational programs and products
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Military Curriculum Materials for Vocational and Technical Education

Information and Field Services Division

The National Center for Research in Vocational Education

Military Curriculum Materials Dissemination Is . . .

an activity to increase the accessibility of military-developed curriculum materials to vocational and technical educators.

This project, funded by the U.S. Office of Education, includes the identification and acquisition of curriculum materials in print form from the Coast Guard, Air Force, Army, Marine Corps and Navy.

Access to military curriculum materials is provided through a "Joint Memorandum of Understanding" between the U.S. Office of Education and the Department of Defense.

The acquired materials are reviewed by staff and subject matter specialists, and courses deemed applicable to vocational and technical education are selected for dissemination.

The National Center for Research in Vocational Education is the U.S. Office of Education's designated representative to acquire the materials and conduct the project activities.

Project Staff:

Wesley E. Budke, Ph.D., Director
National Center Clearinghouse

Shirley A. Chase, Ph.D.
Project Director

What Materials Are Available?

One hundred twenty courses on microfiche (thirteen in paper form) and descriptions of each have been provided to the vocational Curriculum Coordination Centers and other instructional materials agencies for dissemination.

Course materials include programmed instruction, curriculum outlines, instructor guides, student workbooks and technical manuals.

The 120 courses represent the following sixteen vocational subject areas:

- Agriculture
- Aviation
- Building & Construction Trades
- Clerical Occupations
- Communications
- Drafting
- Electronics
- Engine Mechanics
- Food Service
- Health
- Heating & Air Conditioning
- Machine Shop
- Management & Supervision
- Meteorology & Navigation
- Photography
- Public Service

The number of courses and the subject areas represented will expand as additional materials with application to vocational and technical education are identified and selected for dissemination.

How Can These Materials Be Obtained?

Contact the Curriculum Coordination Center in your region for information on obtaining materials (e.g., availability and cost). They will respond to your request directly or refer you to an instructional materials agency closer to you.

CURRICULUM COORDINATION CENTERS

EAST CENTRAL
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100 North First Street
Springfield, IL 62777
217/782-0759

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405/377-2000

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SCHOOL CODE
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SUBCOURSE
[illegible]

U.S. Army Training Support Center

Fort Eustis, Virginia

ACCP

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ARMY CORRESPONDENCE COURSE PROGRAM

-- IMPORTANT --

STUDY THIS SHEET

before beginning the subcourse

General

Your cooperation in following these instructions will

--enable you to make the maximum rating commensurate with your ability.
--help us to process your lessons promptly and efficiently.

Scan the CHECKLIST OF TEXTS AND MATERIALS FURNISHED.
Scan the INTRODUCTION to the subcourse.

Procedure

--Beginning with Lesson 1, scan the LESSON ASSIGNMENT SHEET. It lists the lesson title, lesson objective, credit hours required, texts required, and suggestions.

--When the words STUDY TEXT follow the Lesson Assignment Sheet, the information you must digest is found in a text(s), memorandum, pamphlet, and/or other separate material(s).

--When the words STUDY GUIDE AND ATTACHED MEMORANDUM follow the Lesson Assignment Sheet, the information you must digest is either
  --found in texts and in this subcourse booklet, or
  --found entirely in this booklet.

--When you are referred to a paragraph or an illustration in a manual, turn to the specified paragraph at once and scan or study the text assignment as directed. Continue this procedure until you reach the LESSON EXERCISE.

Lesson Exercise

--Study and answer each question.
--CAUTION: Check to insure that all questions have been answered.
--Your answers MUST be based on subcourse materials, NOT on your experience or opinions.

Assistance

If you require explanation or clarification of subcourse materials or questions, write to the U. S. Army Ordnance Center and School, ATTN: Department of Army Wide Training Support. Constructive comments are appreciated.

Include NAME and SOCIAL SECURITY ACCOUNT NUMBER on all correspondence.

WHEELED VEHICLE CLUTCHES, TRANSMISSIONS, AND TRANSFERS
63B205

Correspondence Course 8-14

Developed by:

United States Army

Development and Review Dates:

October 1975

Occupational Area:

Engine Mechanics

Print Pages:

241

Availability:

ERIC
National Center Clearinghouse

Suggested Background:

None

Target Audiences:

Grades 10-Adult

Organization of Materials:

Text, objectives, exercises, examination

Type of Instruction:

Individualized

Type of Materials:	No. of Pages:	Average Completion Time:
Lesson 1 - Fundamentals of Gears	44	2 Hours
Lesson 2 - Wheeled Vehicle Clutches	30	4 Hours
Lesson 3 - Fundamentals of Conventional Transmissions & Power Takeoffs	42	2 Hours
Lesson 4 - Maintenance of Conventional Transmissions & Power Takeoffs	34	3 Hours
Lesson 5 - Wheeled Vehicle Automatic Transmissions	34	3 Hours
Lesson 6 - Transfer Cases	28	3 Hours
Exercise Response List	28	

Supplementary Materials Required:

None

IA

Course Description:

This course is one of several subcourses that make up the entire correspondence course on wheeled vehicle maintenance. The subcourse is designed to provide the student with information about the operation, malfunction diagnosis, maintenance, and repair of wheeled vehicle clutches, transmissions, and transfer cases. It provides the basic theory, and also includes on-the-job task assignments.

The subcourse is divided into six lessons with objectives, task assignments, and review exercises.

Lesson 1 - Fundamentals of Gears. An explanation of the construction, use, and types of gears and gear trains, and the principles of operation of a simple planetary gear set.

Lesson 2 - Wheeled Vehicle Clutches. An explanation of the construction and operation of friction-type clutches; also a description of inspection, testing, adjustment, and repair of clutch components as applies to the organizational wheeled vehicle repairman.

Lesson 3 - Fundamentals of Conventional Transmissions and Power Takeoffs. An explanation of the construction, operation, and lubrication of transmissions and power takeoffs.

Lesson 4 - Maintenance of Conventional Transmissions and Power Takeoffs. A description of how to inspect, test, adjust and repair parts, and the removal and installation of assemblies.

Lesson 5 - Wheeled Vehicle Automatic Transmissions. A description of the construction and operation of fluid couplings and hydramatic transmissions; principles of lubrication and oil pressure in automatic transmissions; inspection, testing adjustment, and maintenance of hydramatic transmissions; and the removal and replacement of assemblies and repair part components as applicable to the organizational repairman.

Lesson 6 - Transfer Cases. Construction, lubrication, and operation of transfer cases. procedures for inspecting, testing, adjusting, and maintaining transfer cases; and the replacement of assemblies and repair part components.

This subcourse is designed for student self-study, but could be effective in small group learning situations. Each lesson contains objectives, text, and review exercises. Answers for the exercises are provided after the final lesson, along with an examination and application task test.

WHEELED VEHICLE CLUTCHES, TRANSMISSIONS, AND TRANSFERS CORRESPONDENCE COURSE
63B205

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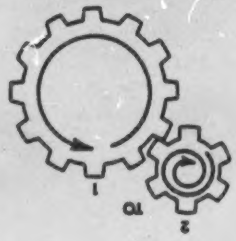
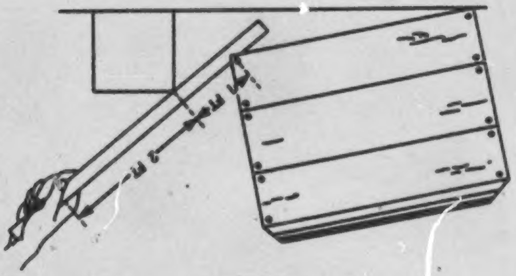
ENLISTED MOS

CORRESPONDENCE/OJT COURSE

ORDNANCE SUBCOURSE 63B205

WHEELED VEHICLE CLUTCHES, TRANSMISSIONS, AND TRANSFERS





LESSON 1

FUNDAMENTALS OF GEARS

OCTOBER 1975

DEPARTMENT OF ARMY WIDE TRAINING SUPPORT
US ARMY ORDNANCE CENTER AND SCHOOL
ABERDEEN PROVING GROUND, MARYLAND

4

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IMPORTANT - Study these directions before going further.

DIRECTIONS FOR THE STUDENT

1. Congratulations. You are starting a new and different type of self-training subcourse called a correspondence/OJT subcourse. It is different from regular subcourses because it has tasks to be practiced on the job in addition to the usual lessons to be studied. This way, you can learn both the job skills and the job knowledge and become completely qualified in the subcourse matter.

2. Of course, you must be able to get to the equipment to practice these tasks. Some of you may not be able to do this. This is why you were asked to pick one of two options, or ways, that you wanted to take the subcourse.

a. If you are enrolled in the correspondence only option, you will study the lessons but you will not practice the tasks on the equipment. This means you will learn only the job knowledge of the subcourse. You will have to practice the job tasks sometime later when you can get to the equipment in order to learn the job skills. You will test yourself after each lesson by answering the lesson exercise questions using your answer sheet. Then you will be tested at the end of the whole subcourse by taking the enclosed multiple choice examination.

b. If you are enrolled in the correspondence/OJT option, you will do the whole subcourse. You will study all the lessons and practice all the tasks listed in each study text on the equipment. This way you will learn both the knowledge and the skills of the subcourse. Then you will be completely qualified in the part of your military occupational specialty (MOS) that is covered by this subcourse. You will test yourself after each lesson by answering the lesson exercise questions using your answer sheet. And, you will also take a subcourse multiple choice examination. However, in addition to these tests, you will take an application task test after finishing the subcourse examination. This application task test will be sent to your unit commander who will see that you are tested on the job tasks. It is important that you practice the tasks while you are studying the lessons so that you will be ready for the task test when you finish the subcourse.

c. You can understand that it is important to remember which of the two options you are enrolled in because the work you must do and the tests you must take will depend upon your option.

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3. This subcourse is one of several subcourses that make up the entire enlisted MOS correspondence/OJT course. If you are enrolled in the entire course, you will take this and all the other subcourses in order. If you are not enrolled in the entire course, then you will only take this and any other subcourses you asked for. Of course, you cannot become qualified in the complete MOS job unless you take the entire course. If you want to take the entire course later, you will be given credit for the subcourse(s) you have already passed.

4. Please check this subcourse packet to make sure that you have the following things:

a. A lesson booklet for each lesson listed in the introduction of lesson 1.

b. A lesson exercise response list and an answer sheet.

c. A multiple choice examination.

If any of these things are missing, please let us know right away.

5. If you are enrolled in the entire enlisted MOS correspondence/OJT course you must finish at least 60 credit hours or three subcourses each enrollment year. Your enrollment year begins the day you receive your first subcourse. If you are enrolled in certain subcourses only, you must finish each subcourse within 6 months after you receive it. However, you should finish each subcourse as quickly as you can so that you will qualify earlier for promotions.

6. You must study the subcourse material starting with lesson 1 and progress through the rest. Beginning with lesson 1, scan the lesson assignment sheet. It lists the lesson title, credit hours assigned to the lesson, lesson objective, study assignment, and suggestions.

a. Go through the lesson exactly as you are told by the study assignment and the suggestions in the lesson assignment. Also follow any directions given throughout the study text.

b. Read the lesson through once; reread and study any portion that you did not understand. After you are sure you understand the study material, answer the exercise questions at the end of the lesson. Then practice the job tasks on the equipment.

US ARMY ORDNANCE CENTER AND SCHOOL
CORRESPONDENCE/OJT COURSE

WHEELED VEHICLE CLUTCHES, TRANSMISSIONS, AND TRANSFERS

(18 Credit Hours)

INTRODUCTION

We now know that an internal combustion engine can develop rotary motion power at the flywheel on the back end of the crankshaft. We also know that anytime rotary motion power is available, it can be made to do work.

Let's see how this type of power is applied to various types of machines. If we think about a little 1-cylinder engine on a lawnmower, the power can be delivered to the mower in one of two ways: by connecting the two units with a belt or by mounting the mower blade directly to the crankshaft of upright engines. Belt driven mowers contain a device for tightening or loosening the belt so that the mower can be started or stopped while the engine is still running. Some rotary mowers having the upright engine use a mechanical device consisting of disks to connect and disconnect the engine from the cutting blade.

These devices are most commonly called clutches. Their purpose is to provide a means of connecting and disconnecting engine power from the machine it is supposed to drive.

The automobile engine must also be disconnected from the vehicle's wheels before the engine can be started. After it is running, the power from the engine must be ready for use as the driver wants it. For instance, he must be able to make the vehicle go by engaging the power smoothly and gradually to prevent twisting or breaking vehicle parts and to keep from jerking the people or load. Some means must also be provided so the engine can make the vehicle go in reverse as well as forward. There must be some way to vary the speed between the engine and the driving wheels so the vehicle will be able to run at high speeds on level roads as well as move heavy loads up steep hills.

Besides furnishing power to make the vehicle move many engines also have to power such things as winches and hydraulic pumps. Units are provided on vehicles for taking power from the engine and applying it to these devices as it is needed. Most Army trucks can be moved by power to all wheels (front and rear) and this too requires additional units to place the engine power at each of the wheels.

For the most part, the tasks described above are done by units called clutches, transmissions, power takeoff's, and transfer cases. It is the job of the mechanic to maintain these units so they will perform their job correctly.

This subcourse is designed to provide you with a knowledge of the construction, operation, and maintenance of these units. The subcourse is organized as follows:

Lesson 1 Fundamentals of Gears.
Scope—An explanation of the construction, use, and types of gears and gear trains, and the principles of operation of a simple planetary gear set.

Lesson 2 Wheeled Vehicle Clutches.
Scope—An explanation of the construction and operation of friction-type clutches; also a description of inspection, testing, adjustment, and repair of clutch components as applies to the organizational wheeled vehicle repairman.

Lesson 3 Fundamentals of Conventional Transmissions and Power Takeoffs.
Scope—An explanation of the construction, operation, and lubrication of transmissions and power takeoffs.

Lesson 4 Maintenance of Conventional Transmissions and Power Takeoffs.
Scope—A description of how to inspect, test, adjust and repair parts, and the removal and installation of assemblies.

Lesson 5 Wheeled Vehicle Automatic Transmissions.

Scope—A description of the construction and operation of fluid couplings and hydramatic transmissions; principles of lubrication and oil pressure in automatic transmissions; inspection, testing adjustment, and maintenance of hydramatic transmissions; and the removal and replacement of assemblies and repair part components as applicable to the organizational repairman.

Lesson 6 Transfer Cases.

Scope—Construction, lubrication, and operation of transfer cases; procedures for inspecting, testing, adjusting, and maintaining transfer cases; and the replacement of assemblies and repair part components.

Examination or application task test.

Scope—The examination is designed to test the student's overall knowledge of the subject material covered in the subcourse. The application task test is designed to test the student's ability to perform tasks associated with the subject material presented in the subcourse.

US ARMY ORDNANCE CENTER AND SCHOOL
CORRESPONDENCE/OJT COURSE

LESSON ASSIGNMENT SHEET

Ordnance Subcourse No 63B205. . . .	Wheeled Vehicle Clutches, Transmissions, and Transfers
Lesson 1.	Fundamentals of Gears
Credit Hours.	Two
Lesson Objectives	After studying this lesson you will be able to: 1. Explain torque. 2. Describe the purpose and types of gears. 3. Describe the operation of gears and gear trains. 4. Explain the principles of gear ratio and torque ratio. 5. Describe the construction of a planetary gear set. 6. Explain the operation of a planetary gear set.

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Text. . . . . Study Guide

Materials Required . . . . Answer sheet and response list

Suggestions . . . . Refer to the illustrations while reading the text.

STUDY TEXT

FOREWORD

Often a man finds himself alone and has to move some heavy object. After several attempts he may find that he just doesn't have the strength. Most any man knows that if he lacks the power for such a task he can use a long bar or a strong stick as a prying tool. In this way he can move objects that are many times his own weight.

The average automotive engine does not provide enough twisting force at the flywheel to propel a car or truck under all conditions without assistance. Just as a pry bar is used by man to do work requiring more strength than he has, devices must be provided for use by the engine.

The engine is aided by parts called gears. Many different types of gears are used and they are arranged in a large number of ways in order to produce the desired results in each case. The mechanic must be familiar with the different types of gears, their arrangements, and how they work in order to determine if they are doing their job right.

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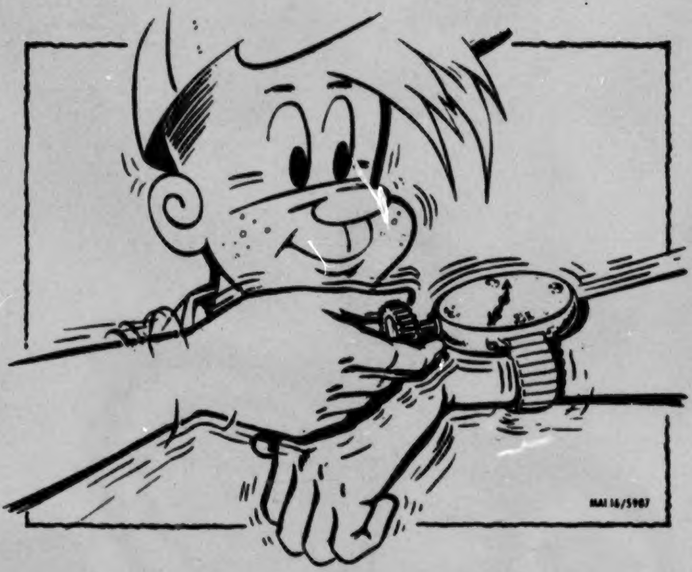
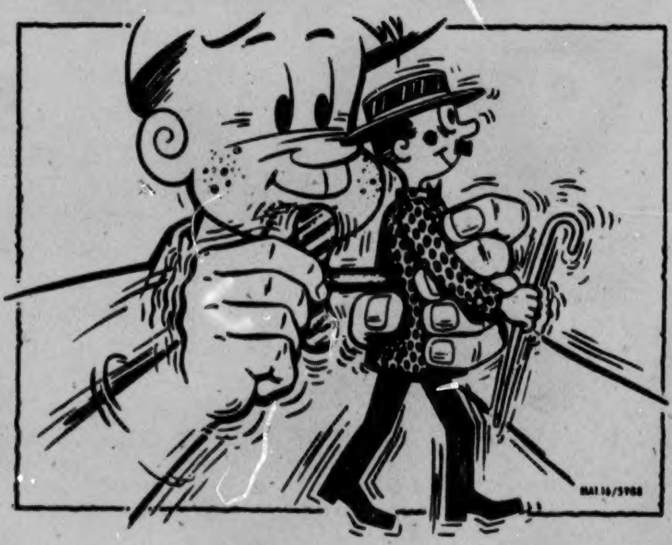
SECTION I. INTRODUCTION TO GEARS

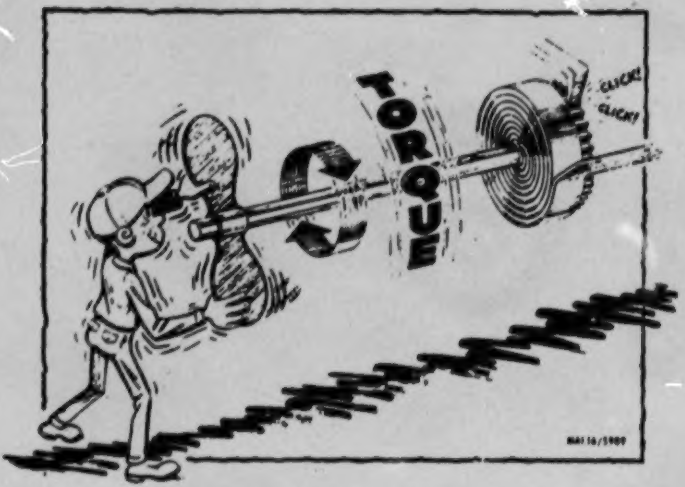
1. PRINCIPLES OF TORQUE. A task that is familiar to each of us is the process of winding our watch. To do this we simply grasp the winding knob between our thumb and forefinger and roll the knob. This action causes a little shaft to rotate inside of the watch which, in turn, causes the watch movement spring to wind.





a. Now let's think of another form of winding action: that of winding a child's toy. Here again, our intent is to wind a spring so that the energy produced by the spring trying to unwind can make the toy work. The key used to wind toys consists of the shank that fits onto the winding shaft and a fairly long finger grip to turn the key. This device is designed for one purpose, and that is to turn the shaft that will wind the spring. However, the toy spring requires more effort to wind than the watch spring so the finger grip is larger than the winding knob of the watch.

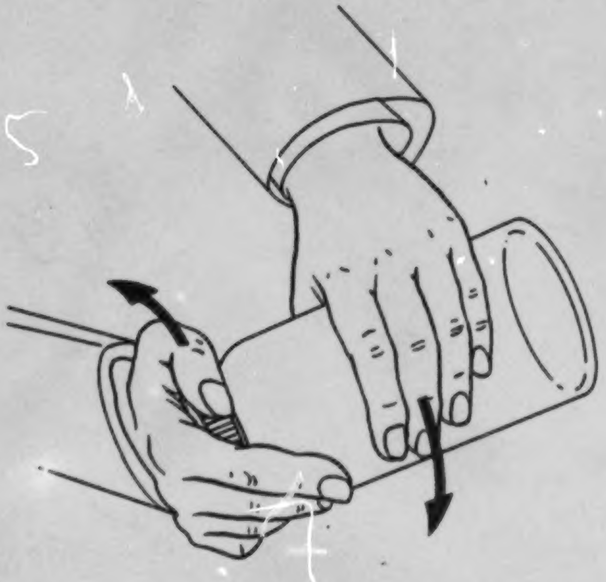
14 b. Suppose we were to try and turn the spring shaft without a key. By gripping it extremely tight we might be able to turn it a little bit, but not enough to wind the spring tight. What is the reason for us not being able to wind it tight?


TORQUE
CLICK!
CLICK!

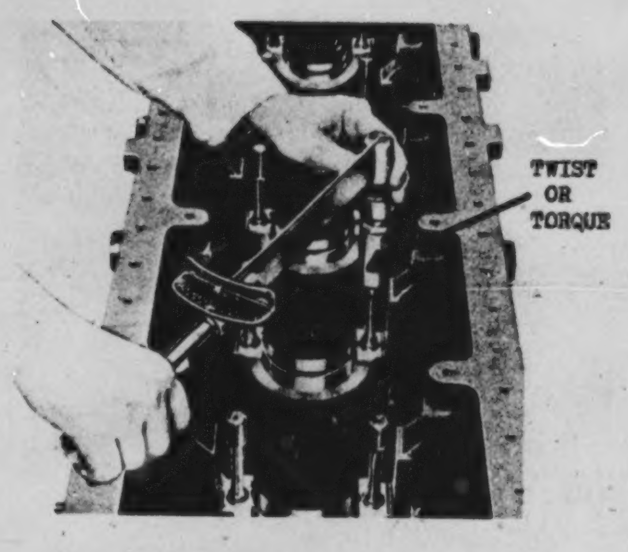
(1) To begin with, the inner end of the shaft is fastened to one end of a coil spring. The natural shape of the spring forms loose coils. When the spring is wound, the position or shape of the coil is changed as they form tightly together. However, a large amount of work is needed to make them take the wound shape because the spring steel tries to remain in an unwound condition. The work involved is the twist that is applied to the winding shaft. This twist or rotating effort applied to the shaft is called TORQUE.

(2) Torque is the twisting effort that is applied to make anything rotate. We usually think of it as the work required to rotate a shaft. However, if you were to grasp one end of a barrel, tip it on its edge and roll it, you would be applying torque to the end you grasped.

(3) The effort used to remove the screw cap from a jar is torque. 15

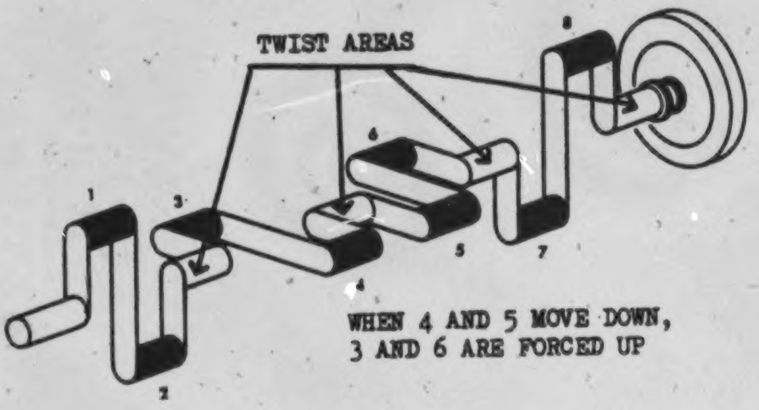


(4) Another example of torque is the use of a wrench on a bolt, nut, or stud. In this case you use a tool to apply twist. But let's stop and think why. We know that we could not apply enough twist with our fingers to tighten or loosen a bolt and nut, and yet it becomes quite simple when we use a wrench. The reason it becomes simple is because the wrench provides a lever action. We also know that if the wrench handle is long we can turn the nut or bolt much easier than with a short handle.



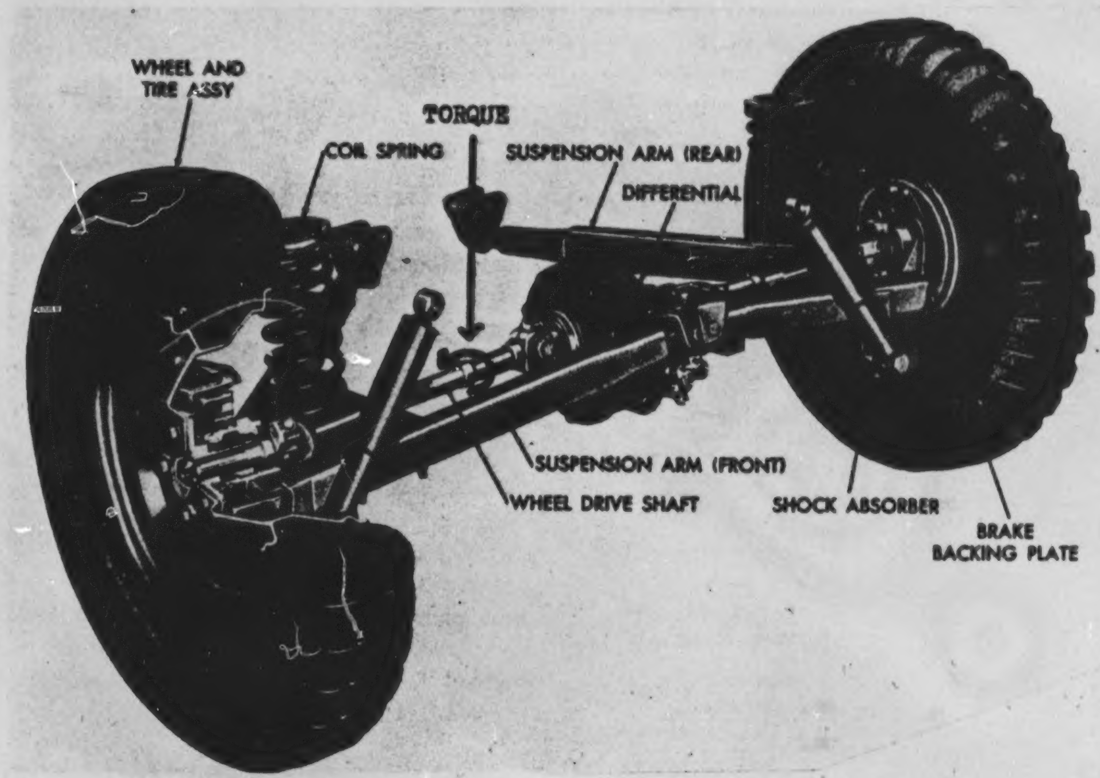
16 (5) Now let's think of the bolt or nut as the spring shaft on a watch or toy. With a wrench on the shaft the spring can be wound quite easily. A person would feel a little foolish winding his watch with a wrench though, so they place a knob on the shaft. The knob is actually a device that is the same as if we had many wrenches sticking out in all directions from the shaft. In other words, the knob being larger than the shaft provides a lever to help overcome the torque required to wind the spring. Keep in mind that torque is twist, and that we can increase twisting effort by using a lever.

c. Now let's look at a couple of examples of where torque fits into a wheeled vehicle mechanic's life.



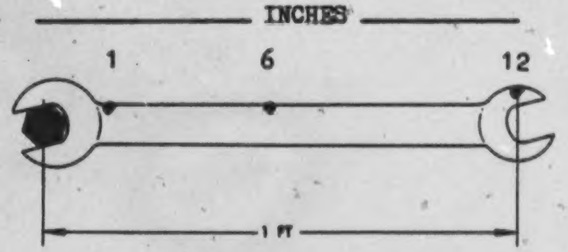
(1) Let's start at the engine. When a piston is forced down on the combustion stroke, its connecting rod forces the crankshaft throw down. Because the crankshaft itself is kept from moving down by its main bearings, the throw forces the shaft to rotate. However, the shaft is hard to rotate because the flywheel resists moving and one or more of the other pistons are being forced up on the compression stroke. Therefore, the power stroke of one piston must apply enough twist to the crankshaft to force the others up on compression stroke and still have power left over to do other work. You can see that a great deal of torque is applied to an engine crankshaft.

(2) The purpose of wheeled vehicles is to transport passengers or cargo. The only way this can be done is for the vehicle wheels to move the vehicle in the direction and speed desired by the operator. This means the wheels must be made to rotate. To do this, torque is applied to the shaft that drives the wheels the same as torque is applied to a wrench for tightening a bolt.

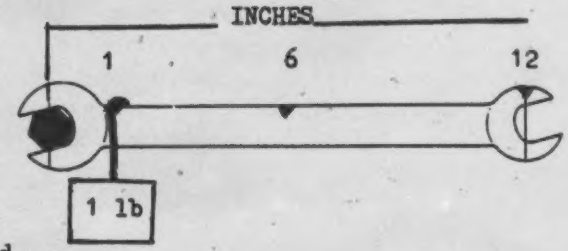


d. The amount of torque or twist that is applied to a shaft or any other given point can be measured. To explain this, let's think about a stud that is being turned into its threads in a piece of metal. For our example we will say that the bolt or stud fits the threads tightly and therefore is quite hard to turn even before it is tightened down.

(1) To explain the measurement of torque we will use a wrench on the bolt. The wrench handle is 12 inches long and is marked at the 1-, 6-, and 12-inch positions. Further, throughout our discussion we will disregard the weight of the wrench.

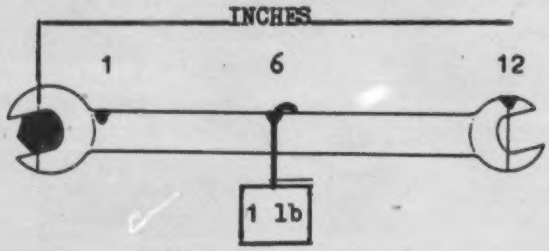


18 (2) With the wrench placed on the bolt we want to turn, we now know that some effort will be needed to turn the wrench. We will take a 1-pound weight to apply the effort. If we place the weight on the 1-inch marking it probably won't be enough to turn the bolt. However, you must agree that there is some twist applied to the bolt. In fact we know exactly how much torque is being applied against the bolt because we have a 1-pound weight pulling down on the wrench 1 inch from the center of the bolt. The term used to express torque is pound-inch or pound-foot. Sometimes you may see these words reversed. Actually, the reversed words (inch-pounds or foot-pounds) are used to express power or work instead of torque. We will use the terms pound-inches and pound-feet in this lesson. In our experiment we have placed 1 pound-inch of twist or torque on the bolt.



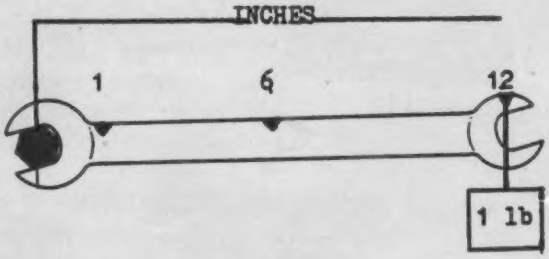
1 pound-inch of torque

(3) As the weight is moved out on the wrench handle, the amount of twist being applied to the bolt will increase. Remember the lever action we spoke about. By moving the weight further out on the handle we are increasing the leverage. If the 1-pound weight was applied at the 6-inch mark it would be applying 6 pound-inches of torque.



6 pound-inches of torque

(4) When the weight is placed on the 12-inch mark it would be applying 12 pound-inches of torque. We can also say that there is 1 pound-foot of torque being applied because the 12 inches is equal to 1 foot. If the wrench was 24 inches long and the weight was placed on the 24-inch mark, we would be applying 24 pound-inches or 2 pound-feet of torque on the bolt.



12 pound-inches or
1 pound-foot of torque

(5) If we remove the weight and grasp the wrench handle with our hand at the 12-inch mark, we can probably turn the bolt. However, for each pound of pressure we apply with our hand we are applying 1 pound-foot of torque on the bolt because our hand is 1 foot from the center of the bolt. When we pull the wrench to apply torque on the bolt and only 15 lb-ft of twist is needed to turn the bolt, that is the greatest amount of torque that can be applied with the wrench until the bolt becomes harder to turn.

e. Now that we understand what effect torque or twist has on a shaft, we will discuss the items used instead of a wrench to turn shafts. These items are called gears.

2. GEARS. Automotive vehicles must have many components that can take the power from the engine and deliver it to the wheels of the vehicle. Not only must the power be simply delivered to the wheels, but the components must be arranged to do several things.

a. Military wheeled vehicles are designed to do the following:

(1) Have great pulling power.

(2) Move at high and low speeds.

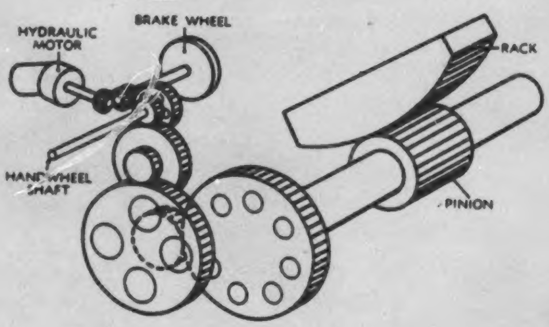
(3) Travel in reverse as well as forward.

(4) Operate on rough ground as well as smooth roads.

(5) Deliver power to the front wheels as well as the rear wheels.

b. A simple shaft, belt, or chain from the engine to the wheels would not allow all of these things to be done. Therefore, components often referred to as gearboxes make up what is referred to as the power train of a vehicle. These units contain various types of gears to do the job.

c. Gears are made in many shapes and sizes. Their purpose is to transmit power from one shaft to another. The shafts might be parallel to each other or at an angle with each other.



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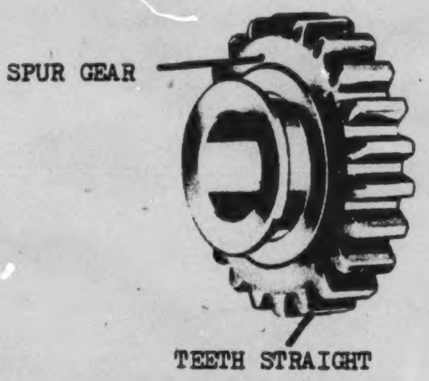
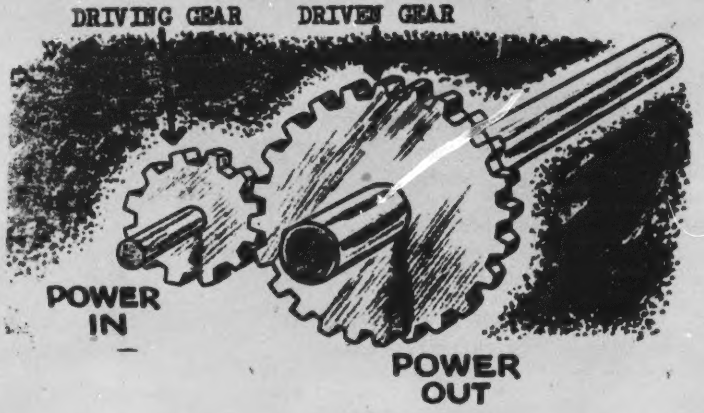
3. TYPES OF GEARS. You can now see that gears must be shaped for the job they are to do. All gears have certain common features. Usually they are a round wheel with teeth or notches formed some way on the outer edge. They will have a hole in the center so that they can be mounted on a shaft.

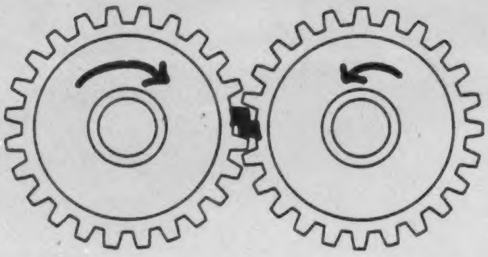
a. The spur gear can be identified by its straight teeth. Notice that the teeth are all spaced evenly and run straight across the outer face of the gear. This type is called an external tooth gear because the teeth are on the outside. This is the most common type of gear we will see. It can be used to transmit power from one shaft to another as long as the two shafts are parallel.



(1) When two of these gears are in mesh, one can turn the other. The one that is doing the driving is called the pinion or driving gear and the one being turned is called the driven gear.



(2) Notice that when these gears are in mesh, only one tooth of each gear is in contact. This means that the entire load is being driven through one tooth in each gear. As one tooth comes out of mesh, another moves in to take its place. Therefore, there are two things that aren't so good about this gear. By having only one tooth engaged at a time, large loads might break off a tooth. Also, the one tooth going into and out of mesh at a time causes these gears to be noisy.



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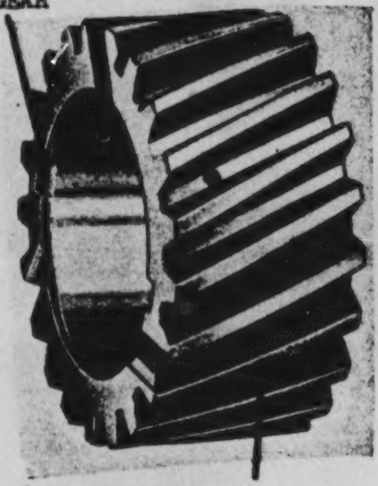
b. Another type of gear is the helical tooth gear. Notice that the teeth of this gear are cut at an angle. This makes the teeth longer and when two gears are in mesh, portions of two or more teeth are in contact all the time.

HELICAL GEAR



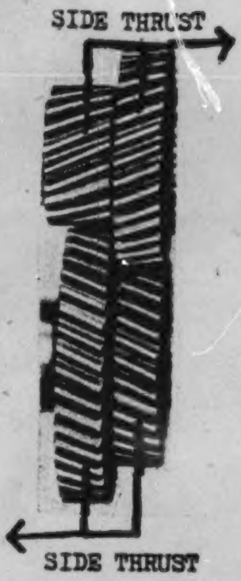
TEETH AT AN ANGLE

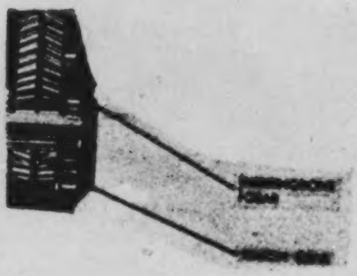
MORE THAN ONE
TOOTH IN CONTACT

(1) Since the force of a load on this type of gear is spread over a larger area, the helical tooth gears can handle larger loads than spur gears can. Also, because of the way the teeth engage and disengage with each other these gears are fairly quiet.

30

22 (2) However, there is a big disadvantage to this type of gear. Whenever a helical gear is driving another gear under load, the gears try to slide sideways on their shafts because of the shape of the teeth. The driving gear will try to slide the other way. This action is called side thrust, and when these gears are used the shafts must be designed to prevent the gears from moving sideways.



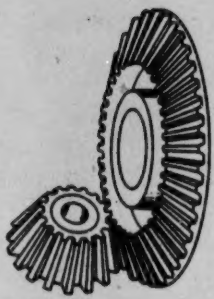


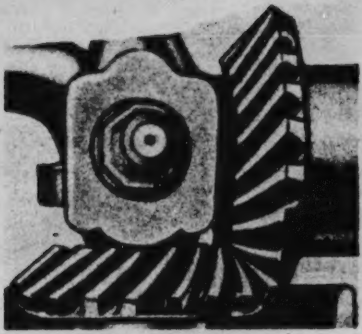
c. There are times when gears must be made to handle extremely heavy loads. In order to use the helical principle where long tooth contact is available, a double helical gear called a herringbone gear was designed. You will notice that there is no side thrust on this type of gear because of its shape. This gear is also fairly quiet.

d. When power must be delivered at an angle, the teeth of the gears must be cut differently. This type of gear is called a bevel gear. Notice that two of them in mesh will change the direction of power by 90°. These gears are available in several designs.

23

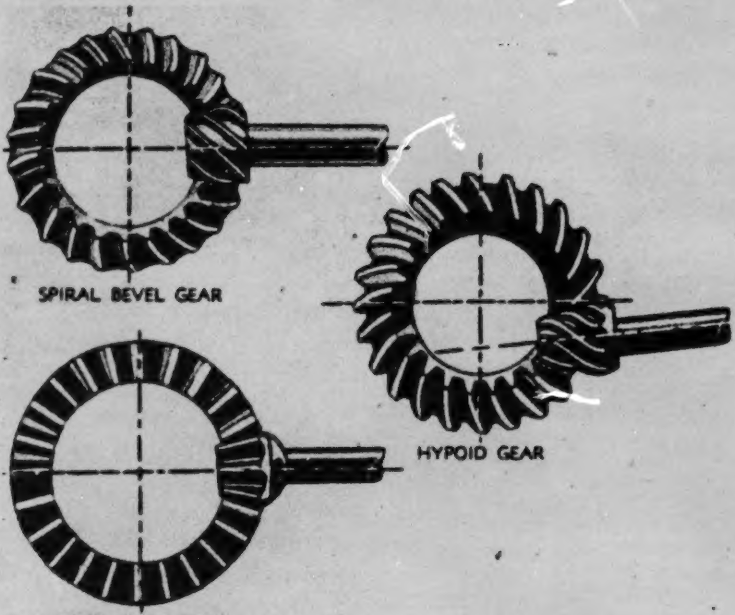
(1) The spur bevel has straight teeth the same as the regular spur gear, except that they are cut at a 45° angle to the side of the gear.



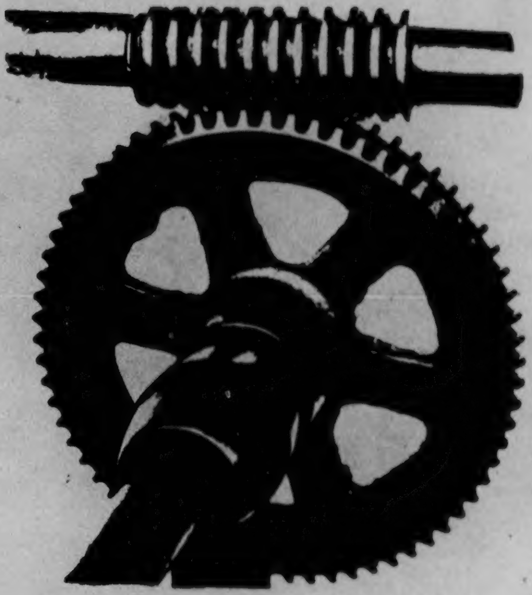


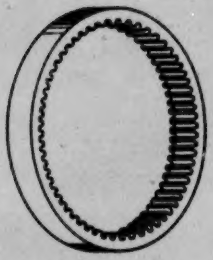
(2) The skew bevel gear is cut similar to the helical gear, except that the teeth are also cut at a 45° angle to the side of the gear. The advantages of the skew bevel gear over the spur bevel gear are the same as those of the helical gear over the spur gear.

(3) There are other designs of this type of gear such as spiral bevel and hypoid which are used in the rear and front axles of vehicles. These will be discussed in a later subcourse on axles.



24e. The worm gear is another type of gear for delivering power at an angle. The principle of this gear arrangement is similar to a bolt and nut. The worm shaft has a coarse thread cut on it. As it rotates, it winds the teeth of the worm gear into it. This is very compact and quiet and is often used where heavy loads must be transmitted at an angle.

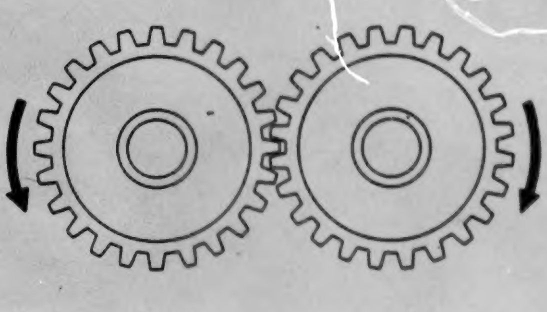




f. Another type of gear is the internal tooth gear. This is a ring with gear teeth cut on the inside. The teeth are usually of the spur type (straight across). This type gear is normally used for special purposes only.

4. GEAR PRINCIPLES. The speed and direction of rotation of shafts that are gear operated will depend on how the gears are arranged.

a. When two external tooth gears are in mesh they will turn in opposite directions. This principle can be used to provide forward and reverse gears on a vehicle.



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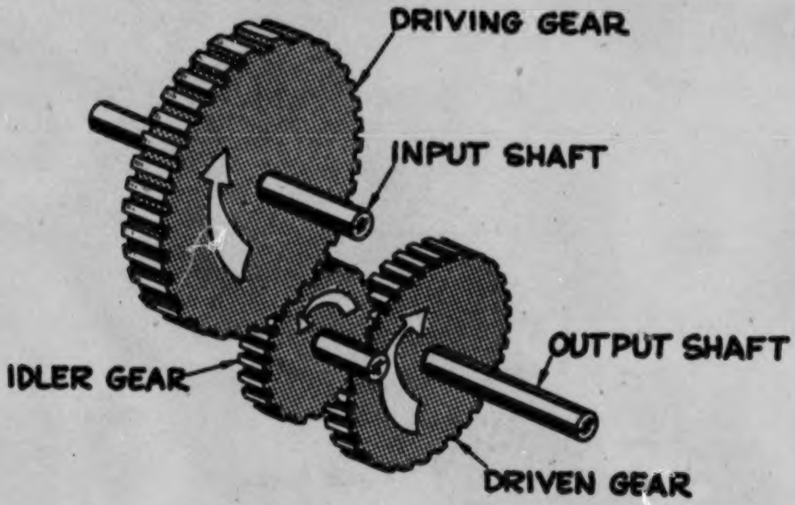
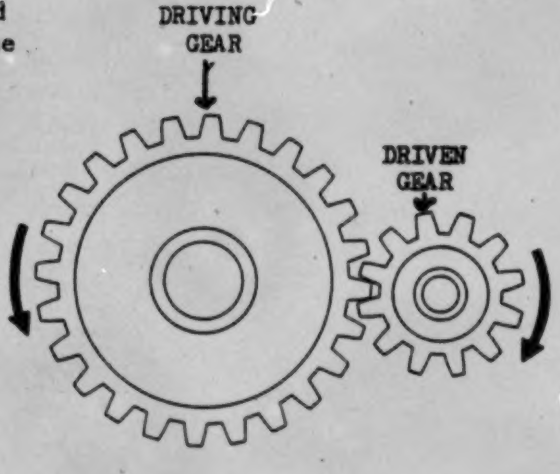
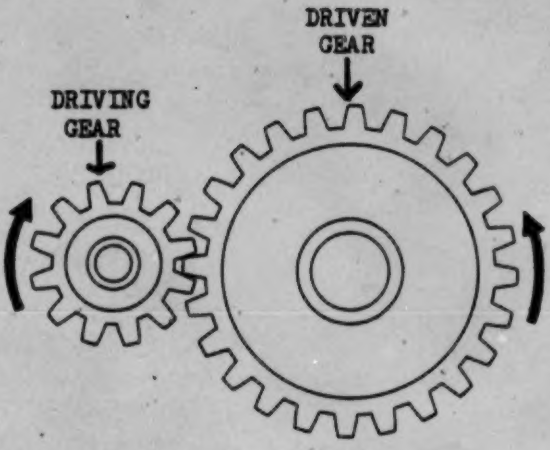
b. When a third gear is added to a gear train it is called an idler gear. The driving and driven gears will turn in the same direction. The idler gear will rotate opposite from the driving and driven gears and will not change the speed or torque of the driven gear.



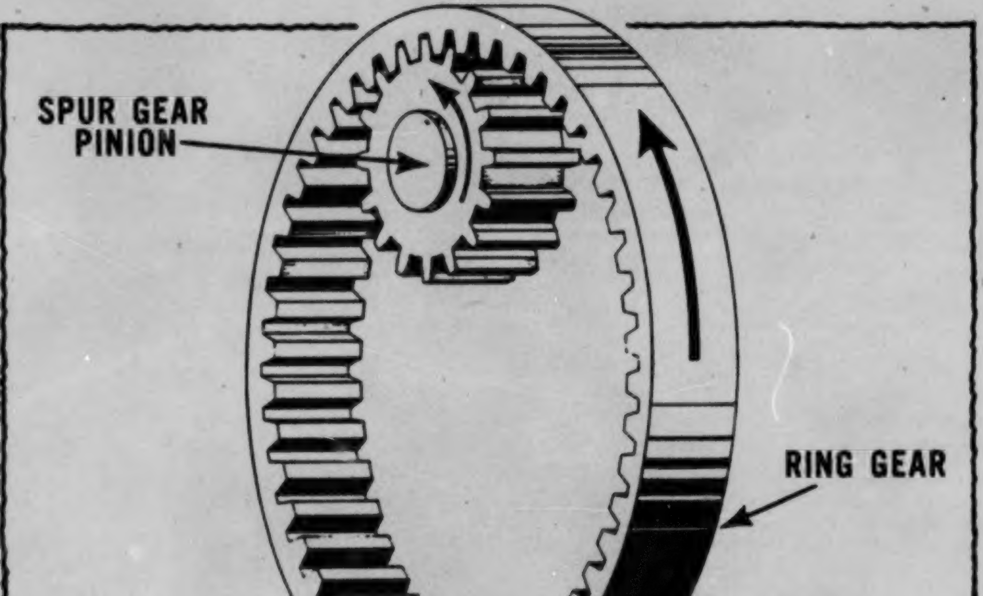
c. A large driving gear meshed with a small driven gear will increase speed, reverse direction of rotation, and reduce the amount of torque delivered.



26 d. A small driving gear meshed with a large driven gear will decrease speed, change direction of rotation, and increase the amount of torque delivered.

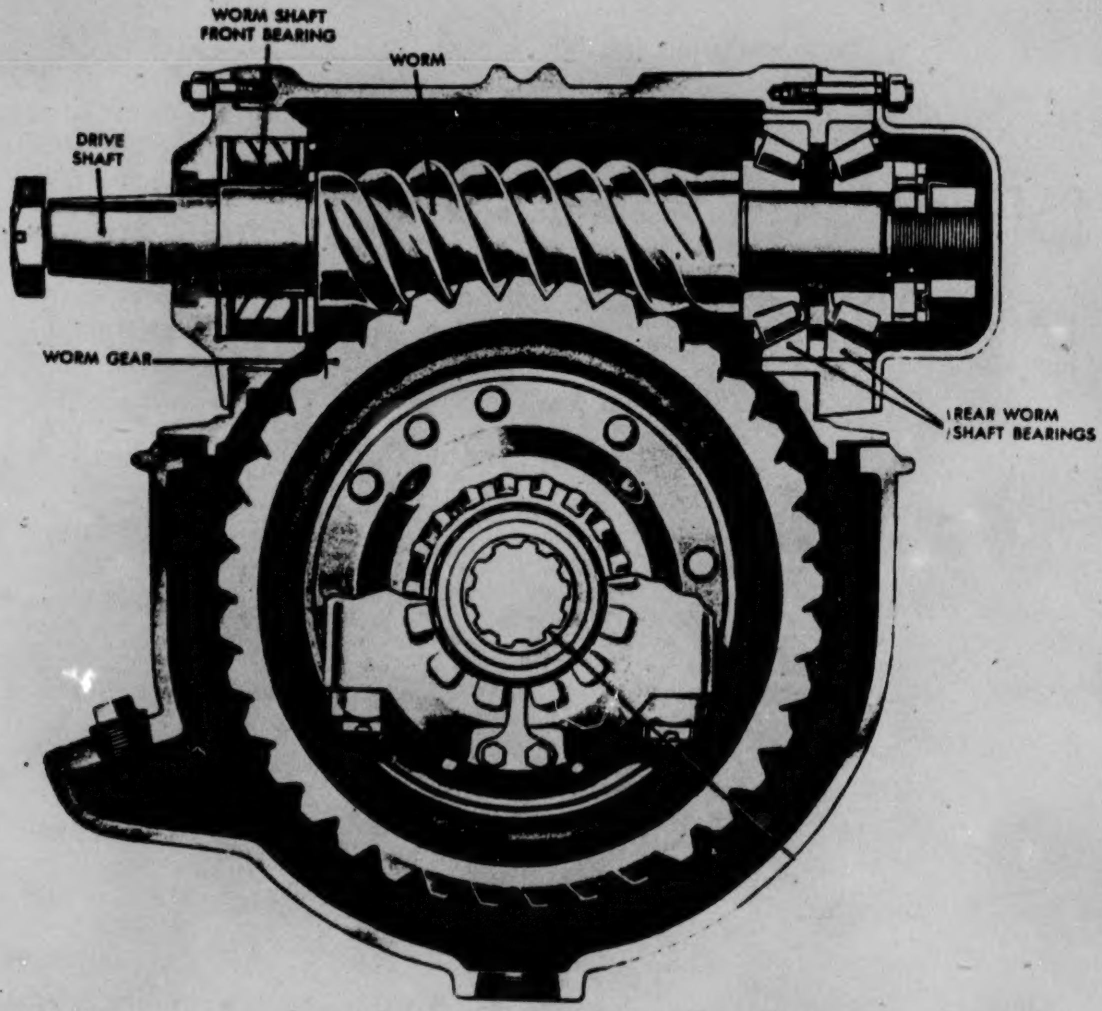


e. An internal gear meshed with and driving an external gear will increase speed and decrease torque. An external gear meshed with and driving an internal gear will decrease speed and increase torque. Both gears will always turn in the same direction.



BOTH TURN IN SAME DIRECTION

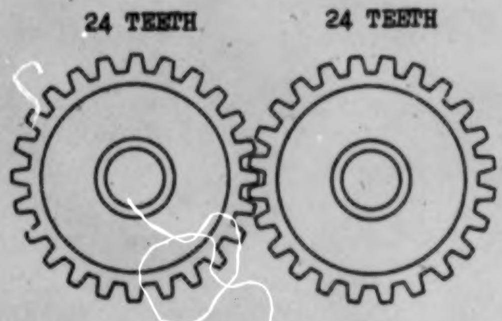
f. A worm shaft driving a worm gear will deliver power at a 90° angle. The worm shaft is always the driving or input member. For each rotation of a single thread worm shaft the worm gear will rotate the distance of 1 tooth. Speed and torque ratio of a worm gearset is therefore determined by comparing the number of threads on the worm shaft to the number of teeth on the worm gear. Worm shafts are designed with single or double threads.



5. GEAR RATIO. The term gear ratio is used to express the comparison of the speed of rotation between two gears. It is always stated with the first number representing the rotation of the driving gear and the second number that of the driven gear. Also, the first number represents the number of times the driving gear must rotate to make the driven gear rotate one turn.

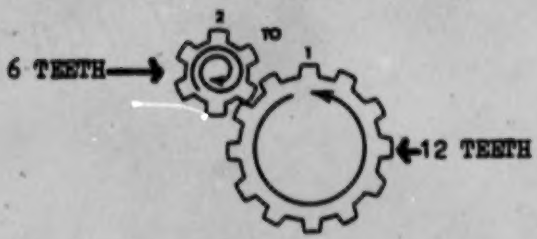
28 a. Some examples of how gear ratio is stated are as follows:

(1) A 1:1 ratio indicates both gears are rotating at the same speed.



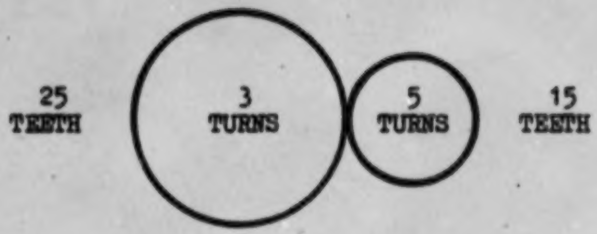
1:1 GEAR RATIO

2:1 GEAR RATIO



(2) A 2:1 ratio indicates that a small driving gear is in mesh with a driven gear twice as big. The driving gear must turn twice to turn the driven gear once.

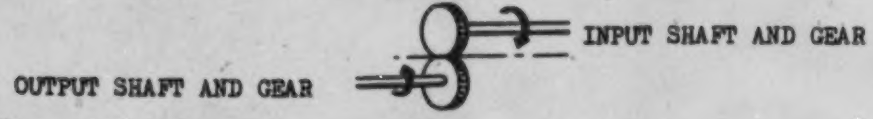
(3) A .6:1 ratio indicates the driving gear is biggest. For every 3 turns it makes, the driven gear will rotate 5 times. Therefore the driving gear only has to make six-tenths of a revolution to rotate the driving gear once.



3:5 GEAR RATIO
OR
.6:1 GEAR RATIO

b. The gear ratio between gears can be determined by counting the teeth of the driving and driven gear. You must remember that when two gears are in mesh, as the driving gear rotates the distance of 1 tooth the driven gear will rotate the same amount.

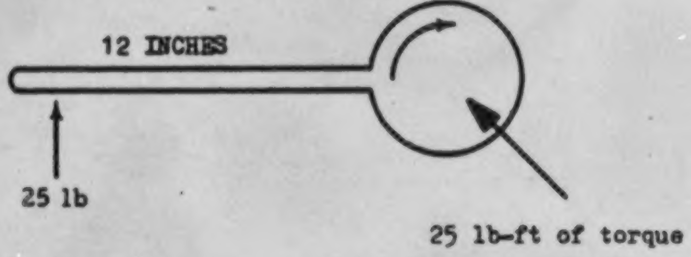
6. **TORQUE RATIO.** To understand the torque ratio of gears it is necessary to understand the principles of leverage as it applies to gears. If you recall, we discussed applying torque to a bolt earlier in the lesson. To discuss torque ratio between gears we must think of the force from a shaft to a gear, from that gear to another gear, and from the second gear to the shaft it is mounted on. To do this we will refer to the items as an input shaft and gear and an output gear and shaft. The input is the driving member and the output is the driven member.



a. Let's first look at the input member. This shaft and gear is bringing the turning force into the gear train. For our purpose here, we will say that an engine or motor is driving the input shaft and is applying 25 pound-feet of torque on the shaft.

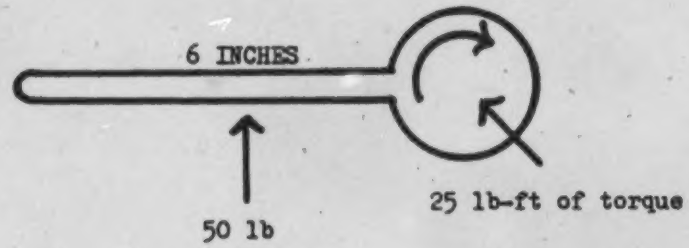
(1) To begin with, we can think of each tooth on a gear as being the same as the lever or wrench we discussed earlier. Remember, when two gears are in mesh, only one or parts of two teeth are touching each other at any one time. Therefore, we must remember that the entire load between two gears is on these teeth.

(2) For our discussion here we will think of the driving gear as having just the one tooth that is going to do the work. Further, to help understand it a little better, we will say that the gear is 2 feet in diameter so the one tooth will be exactly 12 inches long.



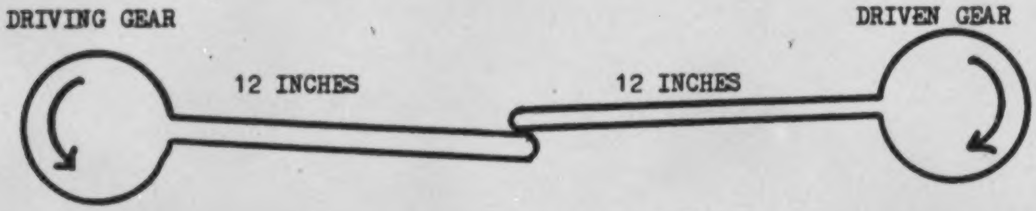
(3) We said that there was a torque of 25 pound-feet applied to the shaft. This means that if the torque was in the direction of rotation as shown by the arrow, it could lift 25 pounds out on the 12-inch mark or at the end of the tooth. You see this is just the reverse of what we explained with the wrench. Here the shaft is turning the gear, with the wrench we wanted to turn the shaft except that we used a bolt instead for our example.

30 (4) By remembering the laws of leverage, we know that a smaller gear will deliver more torque than a larger gear. At the 6-inch mark (the size of a 12-inch gear instead of a 24-inch gear) the tooth could lift 50 pounds because of a greater leverage. You can prove this yourself by holding a stick straight out at arm's length. Have someone hang a small weight out on the very end of the stick. You will notice how hard it is to hold the weight. Now have the person take the weight off the end of the stick and hang twice as much weight on the center. You will see that it requires the same effort to hold twice the weight in the center as it does to hold the single weight on the end.



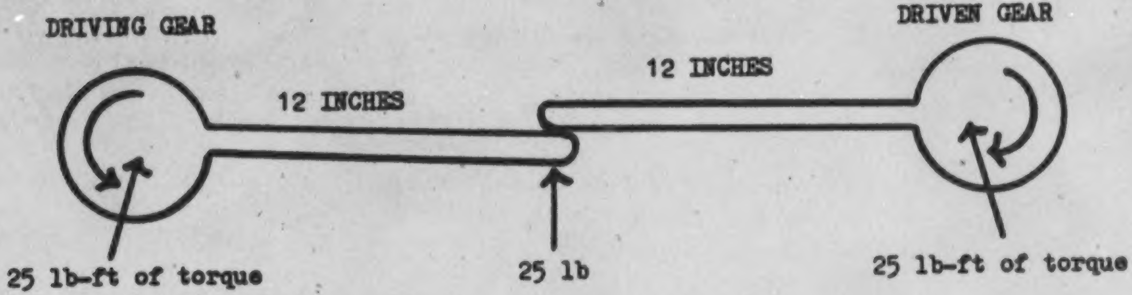
(5) From this we can see that a small driving gear in comparison to the driven gear can deliver more torque (drive a heavier load) than a big gear can. After you have gained experience, you will notice that the driving gear in almost all gear trains is smaller than the driven gear. An exception to this is if you want increased speed instead of torque. Then the input or driving gear would be bigger than the driven gear.

b. Now we will mesh this one tooth of the driving gear with one tooth of a driven gear. Both gears are of the same size.

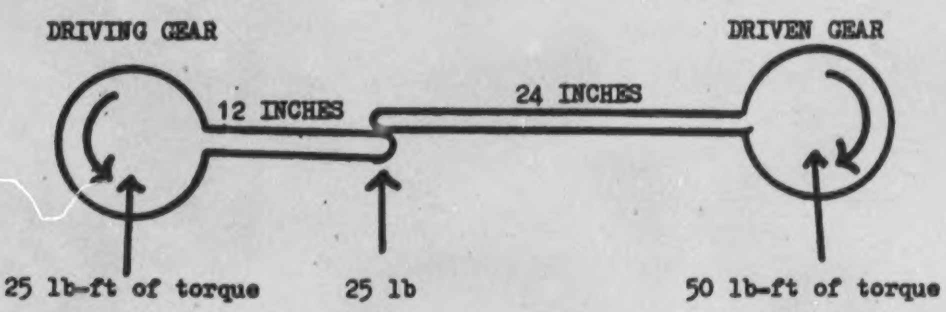


(1) When thinking of the driven member of a gear train, we think of it exactly the same as a bolt with a wrench on it. The longer the wrench is, the easier it is to turn the bolt.

(2) We said that the input gear could apply a force of 25 pounds out on the end. This, then, is the amount of force it will apply to the tooth of the driven gear. Because the tooth of the gear is 1 foot long, a torque of 25 pound-feet will be applied against the shaft on which the driven gear is mounted.



(3) Again, remembering our discussion of the wrench, we know that more effort is required to turn the bolt with a short wrench than with a long wrench. Therefore, if we applied the input force of 25 pounds against an output tooth 24 inches long, we would get twice as much torque on the shaft as on a tooth 12 inches long.



(4) Here again we can compare the output gear to the knob you use to wind your watch. As the knob is made bigger, it is easier to wind the watch. The same principle applies with the driven gear in a gear train. When the driven gear is bigger than the driving gear you can increase torque.

c. How does all of this apply to you as a wheeled vehicle mechanic? Well, let's look at a few things about a wheeled vehicle that depend on gears.

(1) To begin with, the vehicle engine can only produce so much power. When it is running fast it produces more power than when it is idling. The power developed by the engine is sent to the vehicle in the form of twisting motion or torque at the flywheel at the end of the crankshaft.

(2) When the vehicle is started from a standstill, a great deal of torque is required to get it in motion. In addition, the engine is not running at high speed at this time. Therefore, torque from the engine is applied to a small driving gear which in turn drives a large driven gear. This increases torque and helps the engine get the vehicle started.

(3) After a vehicle is in motion, less torque is required to keep it in motion. When this occurs, the driving gear and driven gear can be nearer to the same size. In other words, we want the gear train to develop speed more than torque.

(4) When the vehicle comes to a hill, the ratio will have to be changed again. Now the driving gear will have to be smaller than the driven gear to increase the torque. In doing so, we are giving up speed to increase torque.

d. To sum up torque ratio we can compare it with gear ratio.

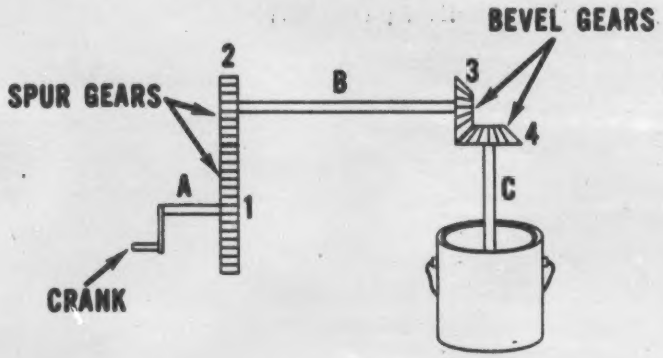
(1) If the driving gear is small with 12 teeth and is driving a large driven gear with 24 teeth, we have a gear ratio of 2:1. In other words, the driving gear has to rotate 2 times to make the driven gear rotate once. In this gear train we double the torque and cut the speed in half.

(2) If the driving gear is the same size as the driven gear the gear ratio is 1:1. The input and output torque and speed are the same.

(3) If the input gear has 24 teeth and the output gear has 12 teeth the gear ratio is .5:1. In this gear train we are reducing torque and increasing speed.

7. OPERATION OF A GEAR TRAIN. To understand how a simple gear train works, refer to the illustration. You will notice that the intent is to stir the bucket of paint by turning the crank.

SIMPLE GEAR TRAIN



a. When the crank is turned, shaft A will cause gear 1 to turn in the same direction as the crank. The amount of torque applied on shaft A will depend on how hard you crank and the resistance of the paint in the bucket.

b. Gear 1 and gear 2 are external gears in mesh and therefore will rotate in opposite directions. Gear 1 being larger than gear 2 will cause gear 2 to turn faster than gear 1 and we therefore have a loss of torque. Remember, in a gear train we must decrease torque to increase speed.

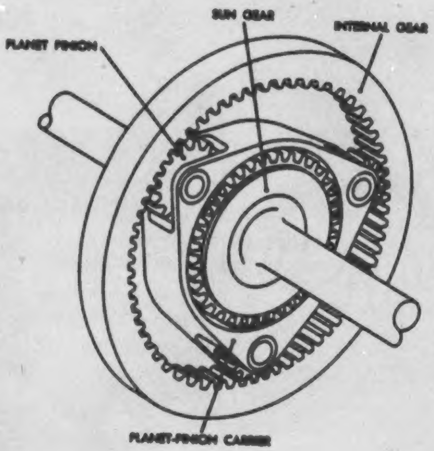
c. Gear 2 and gear 3 are mounted on shaft B which is parallel to shaft A. We have transferred torque from one shaft to another. Gear 3 is in mesh with gear 4 and drives it in the opposite direction of rotation. However, because gears 3 and 4 are bevel gears, the torque is being delivered to shaft C at a 90° angle from shaft B.

d. The rotary motion of shaft C is used to stir the paint.

SECTION II. PRINCIPLES OF PLANETARY GEARSETS.

8. INTRODUCTION. It is often necessary to design gear trains that will provide many gear ratios. Of necessity, these trains must not be too large and bulky. The answer to this requirement is planetary gearing.

a. Notice the arrangement of the components in the set. Because of the resemblance of the planetary pinions to the planets of the universe circling around the sun, the set was given the name planetary gearset.



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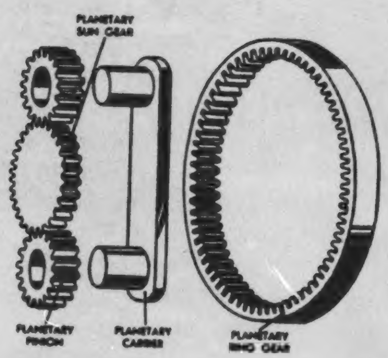
(1) The center or sun gear can be either a spur gear or helical gear. It will contain a through shaft so that it can act as either an input or output member.

(2) Normally, three planetary pinions are in mesh with the sun gear at all times. Some sets will have two and others four. They are mounted on and are free to rotate on individual shafts on the planet carrier, which is a framework designed to hold the pinions in their respective positions. The planet carrier can be rotated so that the pinions walk around the sun gear. The carrier contains a shaft so that it can also act as an input or output member.



(3) The outer internal gear is in constant mesh with the planet pinions and is called the ring gear. It can also be an input or output member.

b. The principle on which the planetary gearset operates is based on driving one unit, holding one unit, and taking the output from the free unit.

(1) If we place a brake band around the ring gear we can prevent it from turning. If the sun gear is driven under this condition it will cause the planet pinions to rotate. With the ring gear held from turning, the planet pinions will have to walk around on the inside of the ring gear and the outside of the sun gear. In doing so, the planet pinions will carry the planet carrier around with them.

(2) If the planet carrier is held so that it cannot rotate and the sun gear is driven, the planet pinions will force the ring gear to turn.

(3) If the planet carrier is held and the ring gear is driven, the planet pinions will force the sun gear to turn.

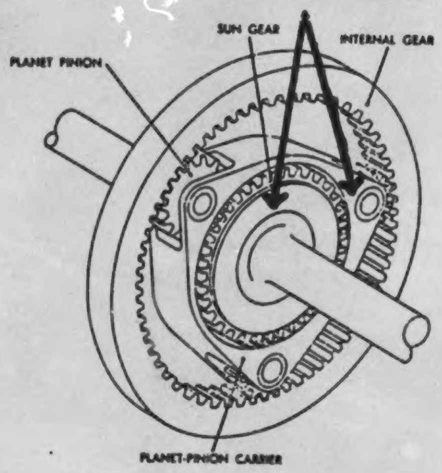
(4) If the sun gear is held and the planet carrier is driven, the planet pinions will be forced to rotate and they will drive the ring gear.

c. In the actual use of planetary gears in such things as automatic transmissions, disk clutches and brake bands control the holding and driving members. Usually the bands and clutches are controlled automatically.

9. OPERATING PRINCIPLES. To fully understand the movement of each member of a planetary system, consider the following:

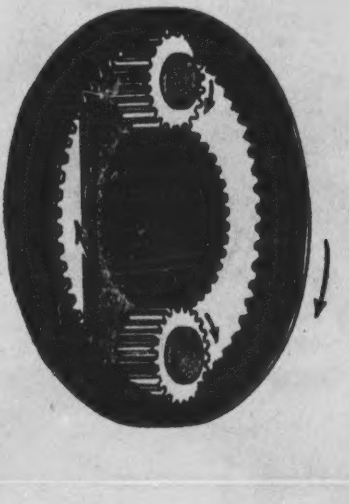
a. If the planetary carrier and the sun gear are held together, the pinions cannot turn because they are locked by the sun gear. This will cause the unit to turn as one unit. None of its parts will turn by themselves. This will give us direct drive just as if we had a one-piece shaft.

PLANET CARRIER AND SUN GEAR LOCKED TOGETHER



OUTPUT - DIRECT DRIVE

b. If the sun gear is held and the planetary carrier is turned, then the ring gear will turn. The pinions will "walk" around the sun gear because the sun gear will not move. The pinions turn as they walk around the sun gear. The pinions are in mesh with the ring gear; therefore, the ring gear is pushed by the turning pinion. The ring gear will turn in the same direction as the carrier.



PLANET CARRIER DRIVEN

SUN GEAR HELD

OUTPUT ON RING GEAR - OVERDRIVE (MORE SPEED, LESS TORQUE)

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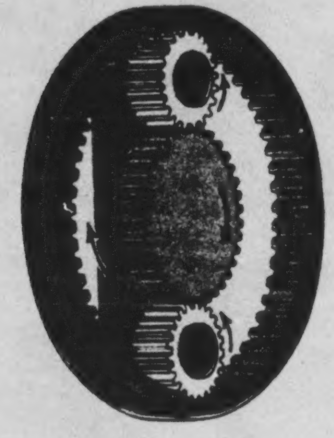
c. If the ring gear is held and the sun gear is turned, then the carrier will turn. The pinions are in mesh with the sun gear. When the sun gear is turned, the pinions will turn. The pinions are also in mesh with the ring gear. The ring gear is held; therefore, the pinions walk around the ring gear. This causes the carrier to turn with the pinions.

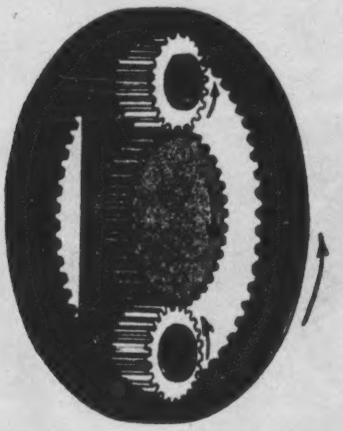


SUN GEAR DRIVEN

RING GEAR HELD

OUTPUT ON PLANET CARRIER -
REDUCTION GEAR (LESS SPEED, MORE TORQUE)

d. If the carrier is held and the sun gear is turned then the ring gear turns in reverse. The pinions are in mesh with the sun gear. When the sun gear is turned, the pinions will turn. The pinions turn in the opposite direction of the sun gear. The pinions are also in mesh with the ring gear. The pinions drive the ring gear because the carrier is held so it cannot turn. When an external gear is driving an internal gear, the direction of turning is the same. Therefore, the planet pinions turning opposite from the input rotate the ring gear in reverse.



SUN GEAR DRIVEN

PLANET CARRIER HELD

OUTPUT ON RING GEAR -
REVERSING REDUCTION GEAR (LESS SPEED, MORE TORQUE, TURNS BACKWARD)

e. There are five basic rules of planetary gear operation:

(1) If the planet carrier is used as the output, the set operates in reduction (slower speed, more torque).

(2) If the planet carrier is the input, the set operates in overdrive (more speed, less torque).

(3) If the planet carrier is held, the set operates in reverse.

(4) If any two parts are locked together, the set operates in direct drive.

(5) If no parts are locked together and if none are held, the set operates in neutral.

f. Here are a few more things you should also remember.

(1) An input member receives power from a source such as an engine.

(2) An output member transmits power to the driving wheels of a vehicle.

(3) A stationary member is one that is held, so it cannot turn, by a band or clutch.

(4) Locked members are held together.

10. SPEED RANGES OF A PLANETARY SET.

Using the first three of the above rules, we can get six speed ranges. Remember that when we reduce speed we increase torque, and when we increase speed we reduce torque.

CONDITION	1	2	3	4	5	6
SUN GEAR	H	H	T	R	I	T
PINION CAGE	T	L	L	H	T	H
INTERNAL GEAR	I	T	H	T	H	LR

H—HOLD
T—TURN
R—REVERSE
I—INCREASE OF SPEED
L—REDUCTION OF SPEED.

a. If the sun gear is held and the planet carrier is turned, the ring gear will turn faster than the carrier (overdrive).

b. If the sun gear is held and the ring gear is turned, the planet carrier will turn slower than the ring gear (reduction).

c. If the ring gear is held and the sun gear is turned, the planet carrier turns slower than the sun gear (reduction).

d. If the planet carrier is held and the ring gear is turned, the sun gear turns in reverse faster than the ring gear (overdrive and reverse).

e. If the ring gear is held and the planet carrier is turned, the sun gear turns faster than the carrier (overdrive).

f. If the planet carrier is held and the sun gear is turned, the ring gear turns in reverse slower than the sun gear (reduction and reverse).

SECTION III. CONCLUSION

11. SUMMARY. From this assignment we have found that all gear trains, both planetary and regular gear type, serve the same purpose; that is, to increase speed and decrease torque, decrease speed and increase torque, change direction of motion (give a reverse), and carry torque from one shaft or gear to another.

a. In regular gear trains, the gears must be shifted by hand. By using planetary gears, the shifting can be done automatically by the use of bands and clutches that are applied or released by oil pressure.

b. You, as automotive repairmen, will be working with both types of gears. Knowing how the unit operates usually makes it a lot easier to find the cause of troubles and how to repair them.

12. PRACTICE TASKS. Appendix B of this lesson contains a list of tasks associated with the fundamentals of gears. They are representative of the tasks you will be required to perform as a wheeled vehicle mechanic. Perform all of the tasks listed. Be sure you are under the supervision of an officer, NCO, or specialist qualified in the MOS when you practice the tasks. If you find you are having difficulty in certain tasks, restudy the appropriate training material and practice the tasks until you become proficient in each one.

LESSON EXERCISE QUESTIONS

Instructions for use of the answer sheet:

1. The procedure by which you will answer the exercise questions in this subcourse is probably new to you. The information is presented in a programed instruction format where you immediately know whether or not you have answered the questions correctly. If you have selected an incorrect answer, you will be directed to a portion of the study text that will provide you with additional information.

2. To use this system proceed as follows:

a. Arrange this subcourse booklet and your answer sheet (on reverse side of response list cover) so that they are convenient. Each exercise question has three choices lettered a, b, and c. Your answer sheet has three groups of numbers for questions 1 through 200. The numbers indicated for each question represent the a, b, or c choices.

b. Read the first exercise question and select the choice you think answers the question correctly. Go to the question 1 area of your answer sheet and circle the 3-digit number that corresponds with the choice you selected.

c. After you have identified the 3-digit number, locate it in the exercise response list. If you selected the right choice, the first word of the response will be "CORRECT." This tells you that you have answered the question correctly. Read the rest of the response which tells why your choice was correct and then go to the next question.

d. If the word "CORRECT" is NOT the first word of the response, you have selected the wrong answer. Read the response and then turn to the area in your study text that is mentioned. There you will find the information necessary for you to make another choice. Line out the incorrect 3-digit response on your answer sheet.

e. After you have reread the reference, select another answer and circle the 3-digit response for that choice. Again check the number of this second choice with the response list to see if your choice is now correct and to obtain more information about your choice. If your second choice is still not correct, line out the 3-digit response on the answer sheet and continue until the correct answer is selected. When you have answered all of the questions in an exercise, count the number of lined out responses and see how well you did.

f. You will notice that the lesson exercise question numbers continue consecutively from lesson to lesson. This allows you to use one answer sheet for the entire subcourse.

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EXERCISE

1. What is a disadvantage of the spur tooth gear?

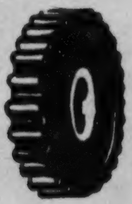
   a. The teeth are machined at right angles
   b. Only one tooth at a time bears force
   c. It can only be used to transmit rotary motion

2. What statement is false with respect to the helical tooth gear?

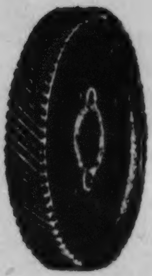
   a. The teeth are set at an angle
   b. It is noisy during operation
   c. The tooth contact area is large

3. What gear when meshed with a similar gear will transmit power at a 90° angle?

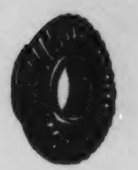
   a.



   b.



   c.



4. In reference to figure 1, what statement is true about the driven gear? 41

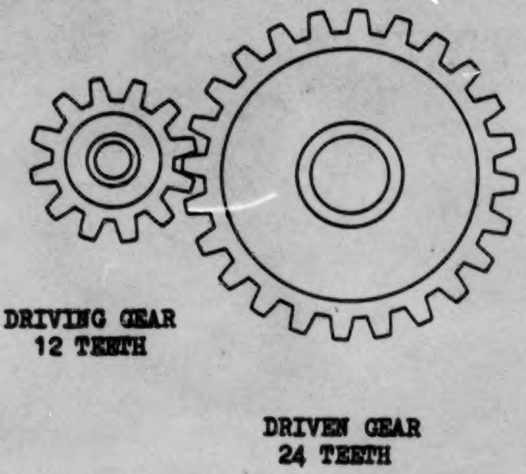


Figure 1

a. It turns in the same direction as the driving gear at half the speed
b. It turns in the opposite direction of the driving gear at twice the speed
c. It turns in the opposite direction of the driving gear at half the speed

5. What pressure will apply the most torque to a bolt?

a. 100 pounds on a wrench 1 foot long
b. 60 pounds on a wrench 2 feet long
c. 30 pounds on a wrench 3 feet long

42 **NOTE.** - QUESTIONS 6 THRU 11 PERTAIN TO FIGURE 2.

6. What are the names of the components of the gear set?

   a. Ring gear, sun gear, and helical gear
   b. Ring gear, sun gear, carrier and pinions
   c. Spur gear, sun gear, carrier and pinions

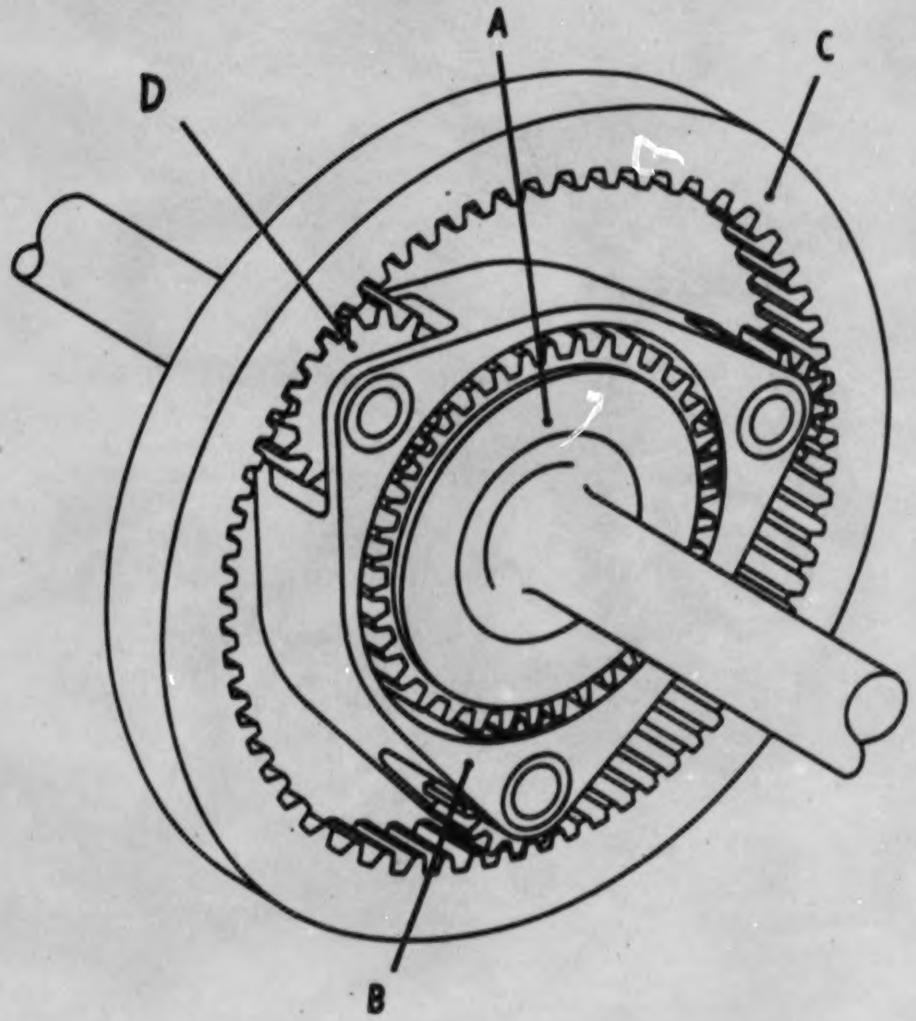


Figure 2

7. If B and C are held together the set will 43

   a. operate in reduction.
   b. turn in reverse.
   c. turn as a unit.

8. What is the result when B is the output member of the set?

   a. The set operates in reduction
   b. The set operates in overdrive
   c. The set operates in neutral

9. If B is held and C is turned, what is the result?

   a. The set operates in neutral
   b. The set operates in direct drive
   c. The set operates in reverse

10. If B is the input member, what is the result?

    a. The set operates in reverse
    b. The set operates in overdrive
    c. The set operates in neutral

11. If none of the members are locked together or held, what is the result?

    a. The set operates in direct drive
    b. The set operates in neutral
    c. The set operates in reduction

12. The effort applied to a shaft to make it turn is called

    a. power.
    b. energy.
    c. torque.

13. What is the result when an external tooth gear drives an external tooth gear?

    a. There is always a reduction in speed
    b. There is always a reduction in torque
    c. There is always a reversal in direction of rotation

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14. What is the result when an internal tooth gear drives an external tooth gear?

    a. Direction of rotation is kept the same
    b. The speed is decreased
    c. The torque is increased

15. One disadvantage of a helical gear is

    a. heavy side thrust is produced.
    b. it can only be used as a driving gear.
    c. only one tooth at a time carries tire load.

APPENDIX A

REFERENCE

TM 9-8000	Principles of Automotive Vehicles	Jan 56

APPENDIX B

PRACTICE TASK LIST

Practice Objectives - After practicing the following tasks you will be able to:

1. Identify the various types of gears used in power train components.

2. Determine the type and ratio of gears required for specific jobs.

3. Assemble gear trains for various speed and torque ranges.

1. Study the power train components of a vehicle in your unit. Determine the following:

   a. The type of gears used.

   b. The gear combinations present.

   c. The approximate gear ratios in each gear train for each combination.

   d. The number of gear shafts in each component.

   e. The input and output members of each component.

2. Secure four external gears of various sizes. Place them on a table surface in such a manner that they will represent the following:

   a. Increased torque transmitted from one shaft to another.

   b. Increased speed transmitted from one shaft to another.

   c. Rotation transmitted in the same direction to another shaft.

3. Determine the gear and torque ratio of each of the three experiments in paragraph 2.

4. Secure a drawing or illustration of a simple planetary gearset. Mentally go through the six speed ranges determining which member is to be held and which one driven.

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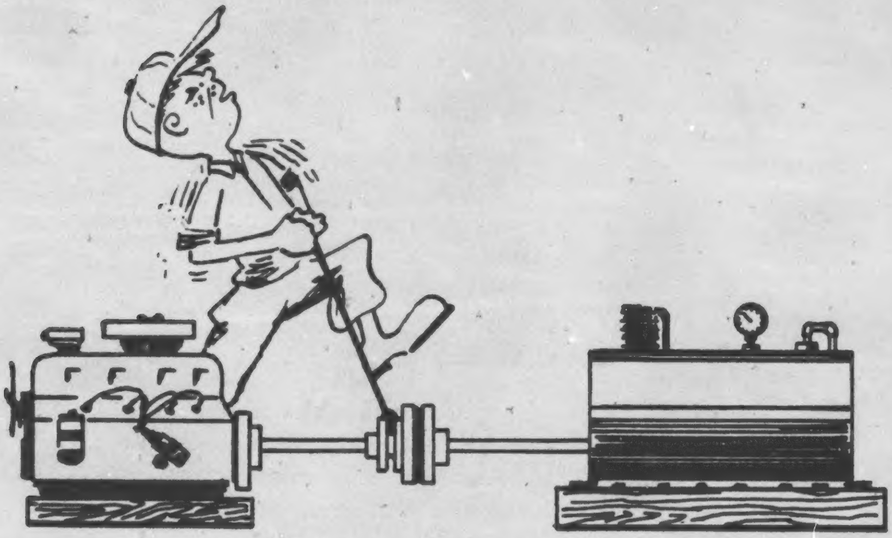
CORRESPONDENCE/OJT COURSE

ORDNANCE SUBCOURSE 63B205



LESSON 2
WHEELED VEHICLE CLUTCHES

OCTOBER 1975

DEPARTMENT OF ARMY WIDE TRAINING SUPPORT
US ARMY ORDNANCE CENTER AND SCHOOL
ABERDEEN PROVING GROUND, MARYLAND

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US ARMY ORDNANCE CENTER AND SCHOOL
CORRESPONDENCE/OJT COURSE

LESSON ASSIGNMENT SHEET

Ordnance Subcourse No 63B205 . .	Wheeled Vehicle Clutches, Transmissions, and Transfers
Lesson 2	Wheeled Vehicle Clutches
Credit Hours	Four
Lesson Objectives	After studying this lesson you will be able to:

1. State the purpose of wheeled vehicle clutches.
2. Describe the construction of wheeled vehicle clutches.
3. Describe the types of clutches.
4. Explain the operation of wheeled vehicle clutches.
5. Describe the procedures for inspecting clutches.
6. Describe the procedures for adjusting clutch linkage.
7. Describe the procedures for removing and replacing wheeled vehicle clutches.

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Text. . . . . Study Text

Materials Required . . . . Answer sheet and response list

Suggestions . . . . Refer to the illustrations as you read the text.

STUDY TEXT

FOREWORD

A clutch is a mechanical device for engaging or disconnecting two members, such as shafts or wheels, so that they turn together or are free to turn independent of each other. There are two broad classes of clutches that are known as positive and friction.

The positive-type clutch may sometimes be called a jaw or dog clutch. These clutches have two members that have matching projections or teeth. The members are mounted independently on two shafts that are in line with each other. The clutch is engaged by bringing the two members together so the projections or teeth mesh, locking the members and shafts together so they turn as one unit. The clutch is disconnected by moving the members apart so they are no longer in mesh. With the positive clutch, power cannot be transferred from one shaft to another gradually.

The friction-type clutch is used in automobiles and trucks because with it the engine crankshaft can be smoothly and gradually connected to shafts that propel the car. Unfortunately, friction clutches are not completely trouble free and often require maintenance from a qualified mechanic, so the mechanic must have a working knowledge of clutches.

SECTION I. CLUTCH CONSTRUCTION AND OPERATION

1. **PURPOSE.** The job of the clutch in a wheeled vehicle is to connect and disconnect the engine power to or from the gears and shafts that drive the wheels. Since the internal combustion engine does not develop too much torque when it is first started, it must be disconnected from the drive mechanism until it has had time to develop enough speed and torque to start moving the vehicle. The engine power can then be gradually applied to provide smooth engagement which will lessen the shock on the driving parts. After the clutch is fully engaged it must transmit all the engine power to the transmission without slipping. The engine power must also be disconnected from the drive system when the gears in the transmission are being shifted from one gear ratio to another.

2. **CONSTRUCTION.** The main parts of the clutch are the driving members, the driven members, and the operating members.

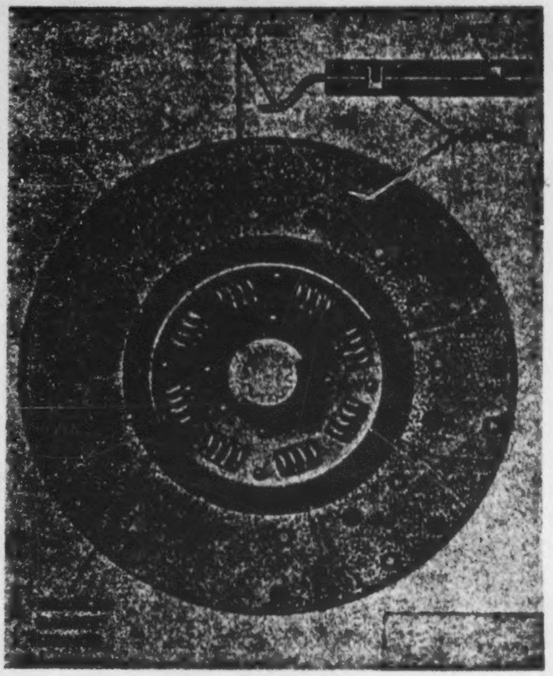
a. The driving members are attached to the engine crankshaft and turn with it. They usually consist of two cast iron plates or flat surfaces machined and ground to a smooth finish. Cast iron is used because it contains enough graphite to provide some lubrication when the driving member is slipping during clutch engagement. One of these surfaces is usually the rear face of the engine flywheel. The other is a heavy flat ring one side of which has a machined surface. This part is known as the pressure plate. It is fitted into a steel cover which also contains some of the operating members and is bolted to the flywheel. We will discuss the operating members contained in this assembly later in the lesson.

Key	Item	Key	Item
A	Bearing throwout	C	Disk assembly
B	Pressure plate assembly	D	Bearing clutch pilot

52 b. The driven member is attached to and turns with the transmission input or clutch shaft, also called main drive pinion. It is a disk with a splined hub and is free to slide on the splines of the shaft, but it drives the shaft through these same splines. The driven member may be called a clutch plate or a clutch disk. We will call it a clutch disk to keep from confusing it with the pressure plate.

(1) The clutch disk is usually made of spring steel in the shape of a single flat disk or a number of flat segments. Facings are attached to each side of the disk by means of copper rivets. These facings must be able to withstand the heat produced by friction when the clutch is slipping. The most commonly used facings are made of cotton and asbestos fibers woven or molded together and impregnated with a binding agent. Very often copper wires are woven or pressed into the material to give it more strength.

(2) To make clutch engagement as smooth as possible and eliminate chatter, several methods have been used to give a little flexibility to the driven disk. One type of disk is "dished" so that the inner and outer edges of the facing make contact with the driving members first and the rest of the facing makes contact gradually as the pressure on the disk increases and the disk flattens out. In another type, the steel segments attached to the splined hub are slightly twisted, which also causes the facings to make gradual contact as the disk flattens out.



(3) The driven member of the clutch usually has a flexible center to absorb the vibrations caused by the crankshaft, which would be sent on through the drive assembly unless they were eliminated. The flexible center is usually made up of steel springs placed between the hub and the steel disk. The springs permit the disk to momentarily turn faster or slower than its hub. At times the springs may be fully compressed, the disk then returns to its original position when the spring decompresses. This slight backward and forward movement, permitted by the spring, allows the clutch shaft to turn at a more steady rate than the crankshaft. This reduces some of the vibration.

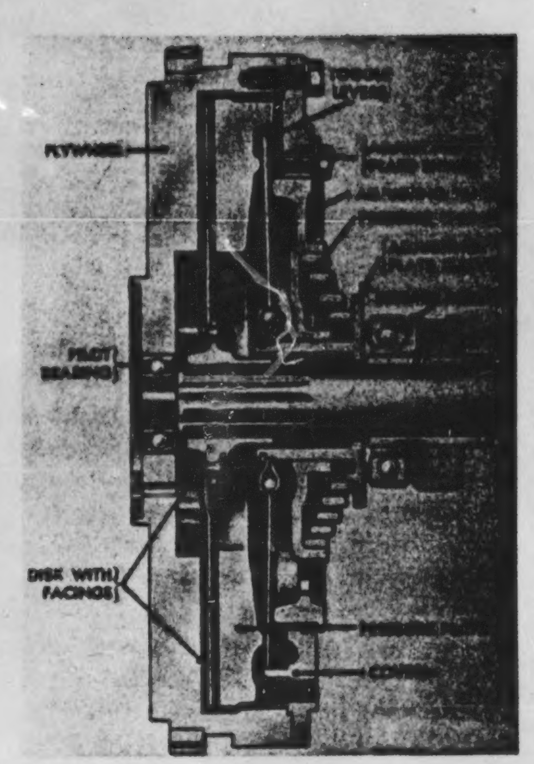
c. The operating members consist of the components required to apply and release the pressure which holds the driving and driven members in contact with each other; they include such things as springs linkage, levers, bearings, etc, depending on the type of clutch.

3. TYPES OF CLUTCHES. There have been several kinds of clutches used on automotive vehicles. They are made to be used on vehicles ranging from small passenger cars to large tractors and tracked vehicles.

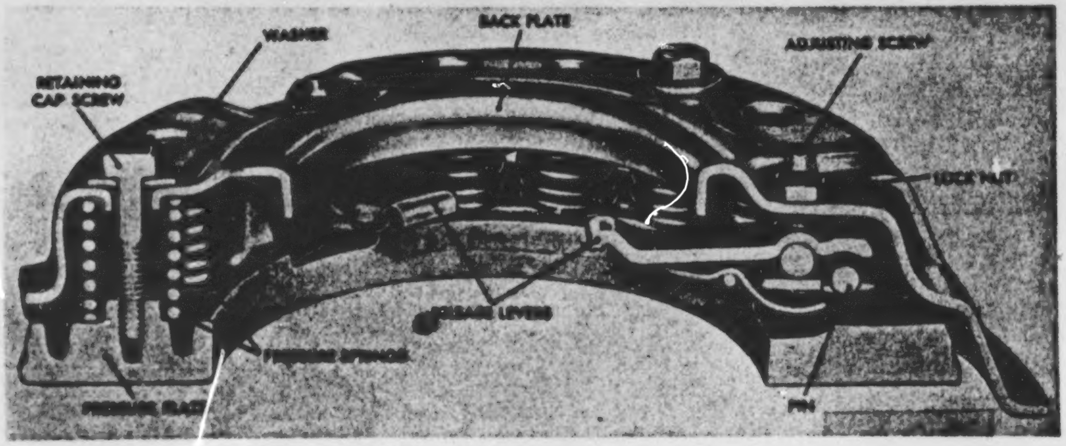
a. One way clutches are classified is by the type of spring used to hold the driving and driven members together. A few of these are single spring, diaphragm spring, and helical spring.

(1) In clutches where the diaphragm is used instead of coil springs, the diaphragm is a cone shaped of spring steel. The diaphragm is mounted between the cover and the pressure plate so that the diaphragm is nearly flat when the clutch is in the engaged position. The action of this type of spring is similar to that of the bottom of an ordinary oilcan. The outer rim of the diaphragm is secured to the pressure plate and is pivoted on rings so that pressure applied at the inner section will cause the outer rim to move away from the flywheel and draw the pressure plate away from the clutch disk, releasing or disengaging the clutch. When the pressure is released from the inner section, the oilcan action of the diaphragm causes the inner section to move out and the movement of the outer rim forces the pressure plate against the clutch disk, engaging the clutch.

(2) In single spring clutches, the pressure plate applies pressure to the clutch disk through an adjusting plate sleeve and a series of toggle levers. When the clutch release bearing moves forward it applies pressure to the lower portion of the toggle lever through the adjusting plate sleeve. This moves the toggle levers away from the pressure plate. The pressure plate is then pulled away from the clutch disk by springs.

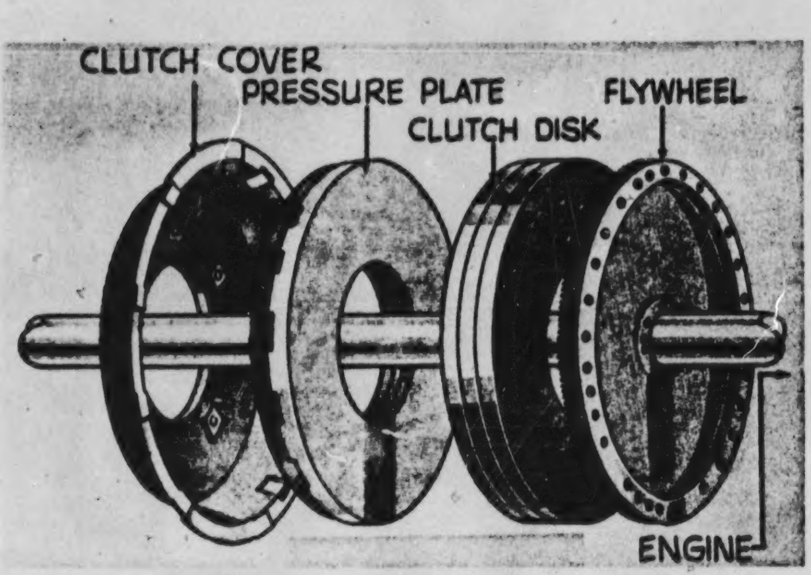


(3) In helical spring clutches a system of levers pivoted on the cover forces the pressure plate away from the driven disk and against the pressure springs when the clutch release bearing moves forward against the inner ends of the levers.

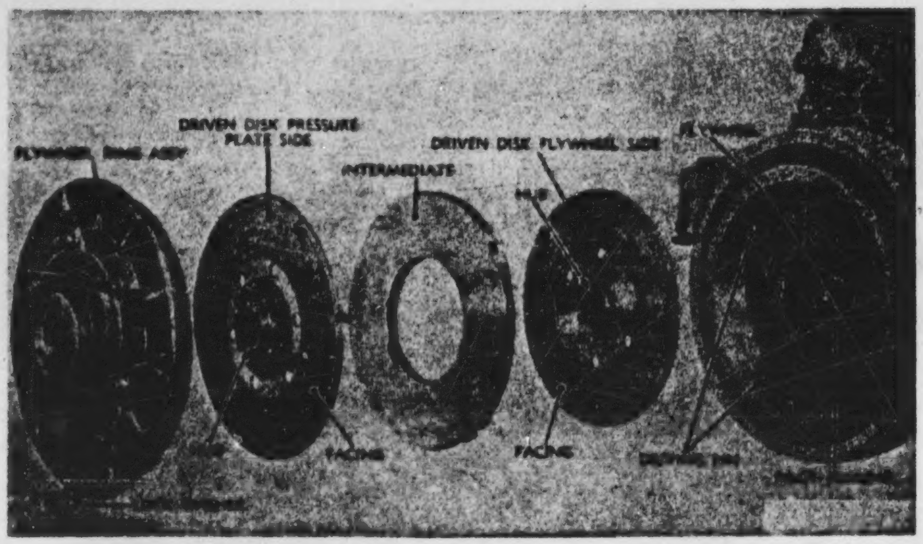


b. Automotive clutches are also classified by the number of plates or disks used in their construction.

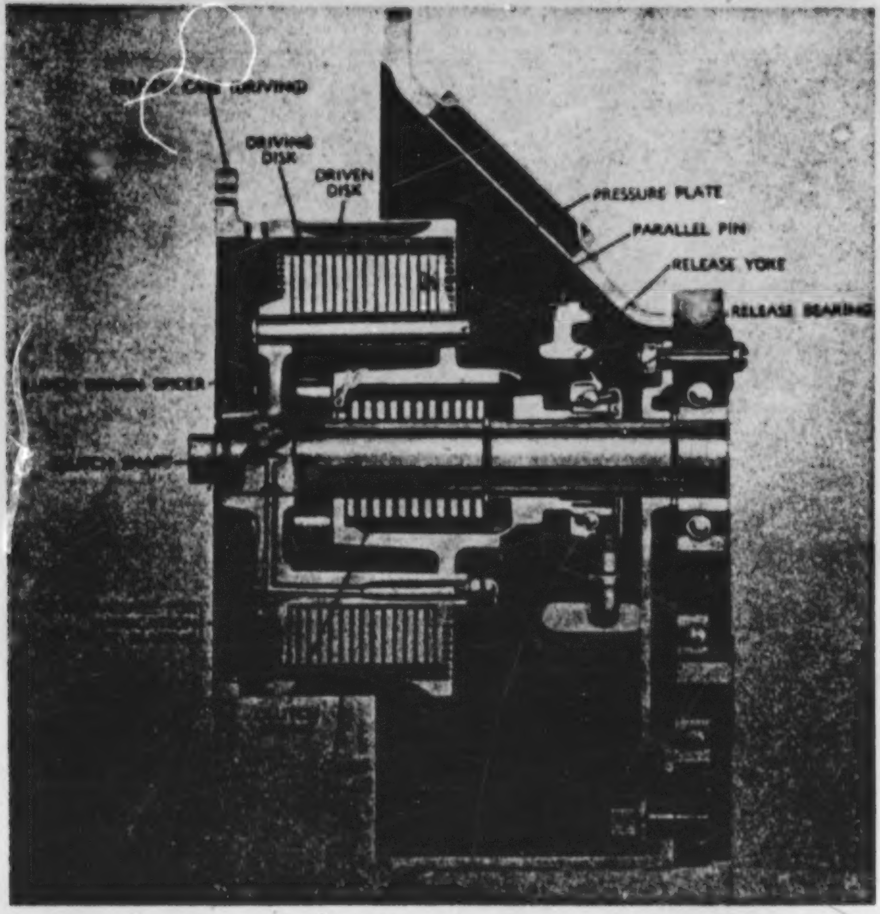
(1) The single plate clutch has one driven disk between the flywheel and the pressure plate. The flywheel is not considered to be a plate even though it acts as one of the driving surfaces.



(2) A double plate clutch is different only in that another disk and plate have been added.



(3) A clutch that has more than three driven disks is called a multiple disk clutch. In this type of clutch, a large number of disks are used, some have eleven driving and ten driven disks. The driving disks have lugs, much like gear teeth, around their outside edges. These mesh with internal splines in the clutch case. The clutch case is bolted to and turns with the flywheel. The driven disks are mounted on pins which are fastened to the clutch spider. This permits the disks and pressure plate to be moved until they do not touch. When the clutch is engaged, springs hold the driven and driving disks together. This causes the clutch spider to turn; the spider then turns the clutch shaft to which it is splined.



(4) Plate clutches are usually used on light or medium weight vehicles and multiple disk clutches on heavier vehicles.

c. Another way clutches are classified is based on whether or not oil is supplied to the friction surfaces. If oil is supplied, the clutch is known as a wet type; if not, it is a dry type.

d. The main difference in the action of clutches is the length of time it takes them to start a vehicle moving. A plate clutch will start a vehicle moving faster than a multiple disk clutch. A dry clutch will act faster than a wet-type clutch. A wet clutch gives a slow smooth engagement which is desirable on heavy vehicles.

4. CLUTCH OPERATION. Most of the clutches you will be working with will probably be plate-type clutches, so let's see just what takes place in the operation of a single plate clutch.

Note. - Refer to the foldout in the back of this pamphlet during the discussion on clutch operation.

a. When the clutch is fully engaged, the driven disk is clamped between the pressure plate and the engine flywheel by the springs.

b. When the clutch pedal is pushed down, linkage from the pedal moves the release yoke or fork on its pivot or hinge. This puts pressure on the release bearing sleeve or collar containing the release bearing. The race of the release bearing pushes against the clutch release levers and moves them on their pivot pins. The outer ends of the release levers move the pressure plate to the rear, compressing the clutch pressure plate spring. This allows the driving members to turn free of the driven members. When the clutch is disengaged, the release bearing turns with the flywheel; the driven disk and the clutch shaft or transmission drive pinion stop turning.

c. When the clutch pedal is allowed to return back out to the engaged position all the parts of the clutch, except the release bearing and collar or sleeve, turn with the flywheel.

SECTION II. CLUTCH MAINTENANCE

5. INTRODUCTION TO CLUTCH MAINTENANCE. Maintenance of clutches by the organizational mechanic includes inspection, adjustment, testing, and repair. The only repair by the organizational mechanic will normally be the replacement of worn or damaged linkage. Inspection and adjustment are probably the most important.

a. When inspecting the clutch, the mechanic should examine the clutch linkage for worn, bent, broken, or damaged parts. Next he should check the clutch pedal free travel. What is free travel? Well let's see just what is meant by this term.

b. Have you ever driven a vehicle that has a clutch pedal? Remember how the pedal is easy to push down a little way, then gets hard to push. The distance that the clutch pedal is easy to push down is called clutch pedal free travel. Another way of saying this is, free travel is the distance the clutch pedal must be pushed down before the clutch starts to disengage.

c. Clutch pedal free travel is caused by slack in the linkage; also, the amount of movement needed before the release bearing starts pushing on the release levers. Clutch pedal free travel should be checked often, as free travel gets less as the clutch wears. Insufficient free travel can keep the clutch from fully engaging. If it is not fully engaged, it may slip and wear out quickly. Too much free travel will cause the clutch not to completely release. This causes the gears to clash and makes it hard to shift gears.

(1) Clutch pedal free travel can be measured by first measuring the distance from the clutch pedal to the floor of the cab.

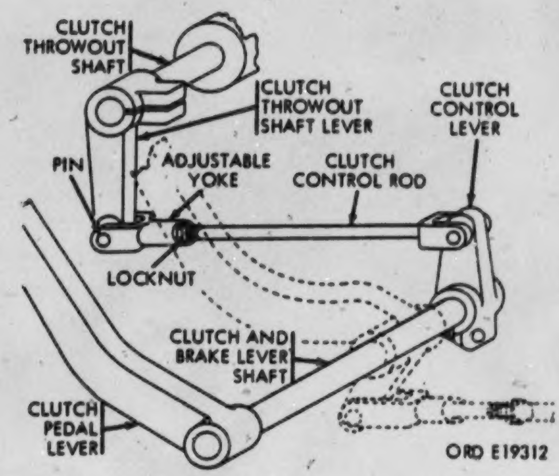
(2) Next push the pedal down until it gets hard to move; again measure the distance from the clutch pedal to the floor. The difference between the two measurements is the clutch pedal free travel.

6. FREE TRAVEL ADJUSTMENT. Although different vehicles have different linkage, free travel adjustment is always made by shortening or lengthening the linkage. An adjusting yoke is usually used to do this.

a. Now let's take a look at how this should be done on a few vehicles. To make a clutch pedal free travel adjustment on an M35A2, 2-1/2-truck, use the following procedures:

(1) Loosen the locknut on the clutch control rod.

(2) Remove the pin connecting the adjustable yoke to the clutch throwout shaft lever.



(3) Turn the yoke either farther onto or off of the clutch control rod until you get the proper free travel, which for this vehicle is 1-1/2 to 2 inches.

(4) Connect the yoke to the clutch throwout shaft lever, replace the pin, and tighten the locknut.

(5) Recheck the clutch pedal free travel.

b. Now for the M151, 1/4-ton truck. To make a clutch pedal free travel adjustment on this vehicle, use the following procedures:

(1) Remove the clutch return spring which is located on the left side of the engine.

(2) Slip the rod out of the equalizer shaft and turn the rod either in or out until the proper pedal free travel is obtained. The free travel on this vehicle should be 1-1/8 to 1-1/2 inches.

(3) Connect the yoke to the clutch throwout shaft lever, replace the pin and tighten the locknut. Recheck the free travel.

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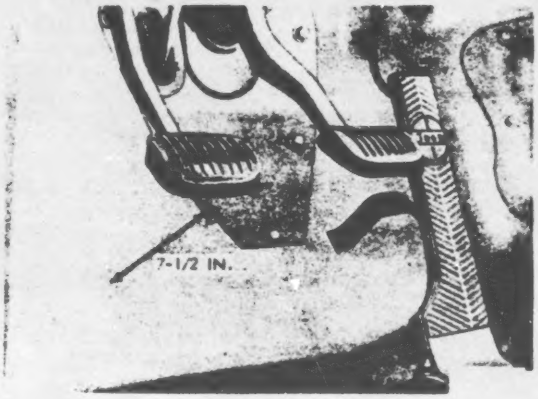
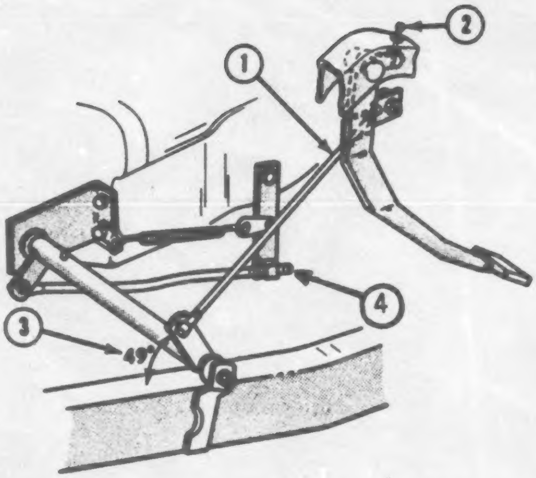
c. The M715, 1-1/4-ton truck, is another vehicle on which you may have to make a clutch pedal free travel adjustment. To adjust the clutch linkage on this vehicle, use the following procedures:

(1) Disconnect the adjusting rod from the clutch pedal.

(2) Turn the adjusting bolt in or out, as required, until the clutch pedal pad is at least 7-1/2 inches from the toe panel and about 1-1/2 inches above the brake pedal.



(3) With the clutch pedal up against the adjusting bolt, adjust the length of the adjusting rod (item 1) so that it can be connected to the pedal. At this time there must be a 49° angle between the frame and the cross shaft lever at the point shown in the figure.



1 Adjusting rod
2 Adjusting bolt
3 49° angle

(4) To adjust the clutch pedal free travel, adjust the cross-shaft-to-throwout lever link (item 4) so that the clutch pedal can be pushed down 3/4 to 1 inch before the clutch starts to disengage.

7. OPERATIONAL CHECK. After the clutch pedal free travel has been checked and adjusted if required, the vehicle should be road tested to see if the clutch is operating properly. During the road test perform the following:

a. Check the clutch for slippage. This can be done by setting the parking brake, place the vehicle in high gear, and try to move the vehicle by slowly engaging the clutch. The engine should stall. The cause of a clutch slipping could be not enough pedal free travel, worn driven disk facings, or a defective pressure plate assembly.

b. Check for clutch chatter. This could be caused by oil or grease on the clutch disk facings or by improper connections. To determine if it is improper connections inspect the transmission mountings, propeller shafts, universal joints, and engine mountings. Tighten as required. If it is oil or grease on the disk facings, the clutch disk will have to be replaced.

c. Check for noise. A squealing noise when the clutch is released but goes away when the clutch is engaged is likely caused by a defective release bearing.

SECTION III. CLUTCH REPLACEMENT

8. INTRODUCTION TO CLUTCH REPLACEMENT. It is not normally the job of the organizational mechanic to replace the clutch. There are several good reasons for this of which a couple are: first, if he is replacing the clutch he is probably using time that should be used in performing routine maintenance, so part of this maintenance may not be done. Second, he will probably not have all of the equipment he needs to do a good job of checking and replacing the clutch assembly. We could also mention a parts problem, for the unit does not stock parts for the clutch.

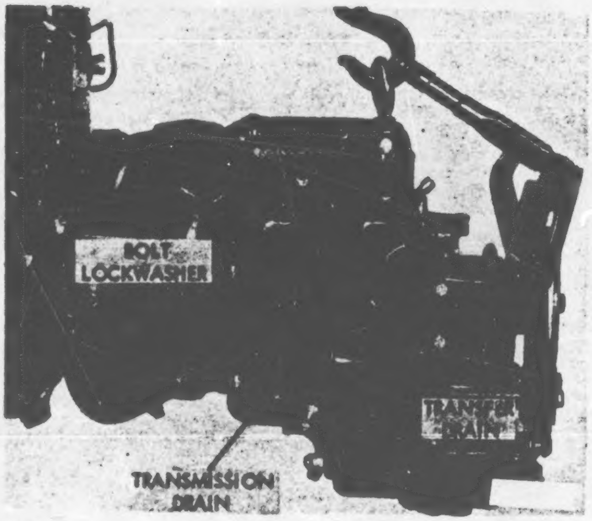
a. If the mechanic is working at the battalion level of maintenance he may sometimes have to replace the clutch. Before he does, the battalion maintenance officer must request and receive permission from their direct support unit. When this happens, the direct support unit will supply the required parts and possibly some of the equipment required.

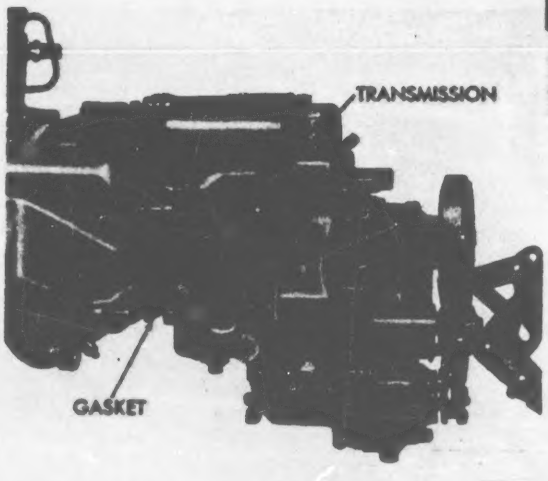
b. If a clutch is to be replaced, the procedures used will be a little different on different vehicles. In any case, the transmission and engine must be separated. This may be done by removing the transmission and leaving the engine in the vehicle, by removing the engine and leaving the transmission in the vehicle, or by removing them together and separating them after they are out. 63

9. CLUTCH REMOVAL. In the M151, 1/4-ton truck, it is not too much of a problem to remove the engine and transmission together. Engine removal is covered in another lesson and is also covered in the vehicle's -20 TM. In this lesson on clutches we are going to say that the engine and transmission have been removed from the vehicle and mounted on an engine stand or supported by wooden blocks, ready for the transmission to be separated from the engine. We will start with separating the engine from the transmission.

a. Remove the transmission from the engine by using the following procedures:

(1) Remove the four bolts and lockwashers that secure the transmission to the engine.

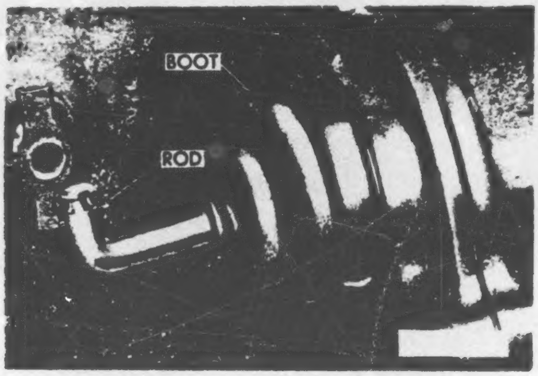




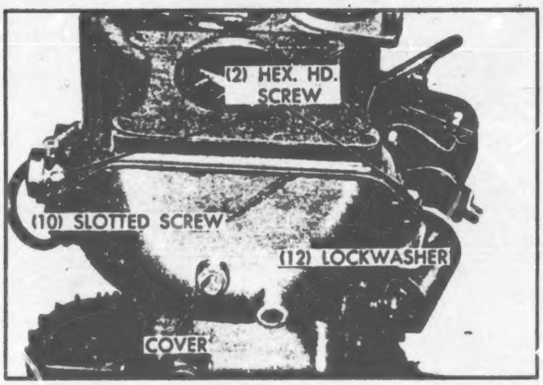
(2) Remove the transmission from the engine. Remove and discard the gasket.

64 b. Remove the clutch assembly by using the following procedures:

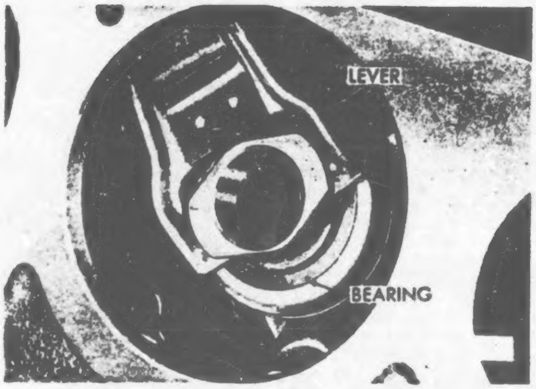
(1) Slip the boot off of the release rod.



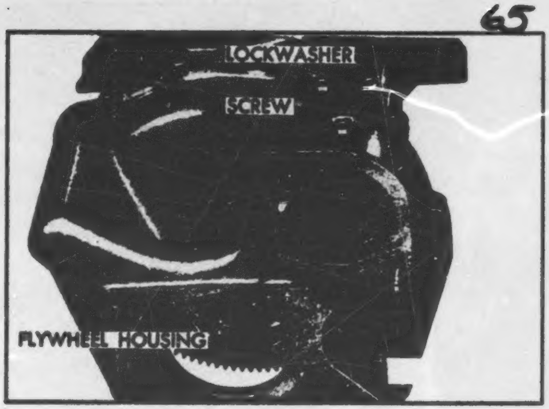
(2) Remove the screws securing the flywheel housing cover to the flywheel housing. Remove the cover and discard the gasket.



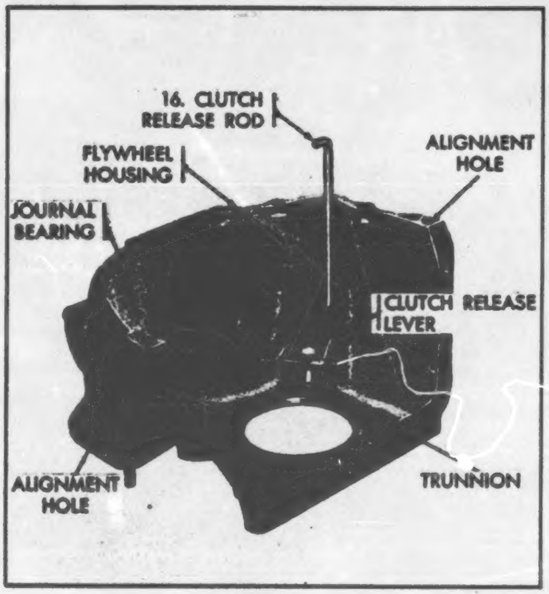
(3) Slip the clutch release bearing out of the clutch release lever.



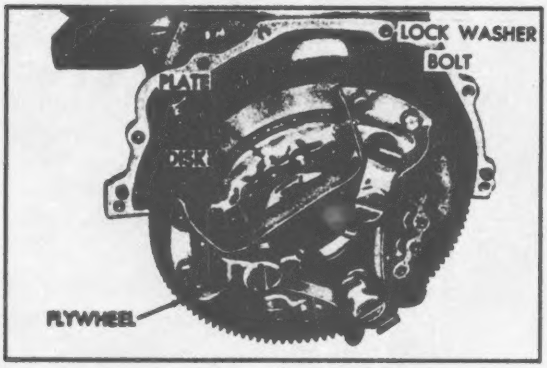
(4) Remove the screws and lockwashers securing the flywheel housing to the engine. Remove the housing and discard the gasket.



(5) If the clutch release lever requires replacement, remove it by pressing it toward the center of the flywheel housing to release the lever from the trunnion ball. Then remove the lever and release rod from the housing.



(6) Loosen the bolts, securing the pressure plate assembly to the flywheel, evenly to release the pressure plate spring tension. Remove the bolts. Remove the pressure plate and driven disk at the same time.



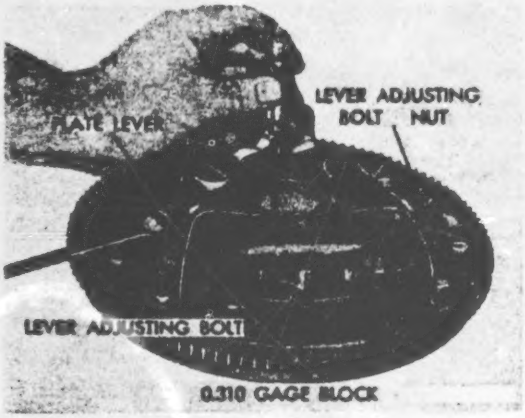
10. CLEANING AND INSPECTION. There are several things that can cause the clutch to have to be removed such as a defective clutch disk, pressure plate, or release bearing. In addition to the part known or suspected of being at fault, all of the other components should be inspected, so we will cover the inspection of all of them.

a. Before inspection the parts should be cleaned. Clean the pressure plate and the surface of the flywheel using cleaning solvent and dry with compressed air. Clean the cover and hub of the disk assembly with compressed air or a clean dry cloth.

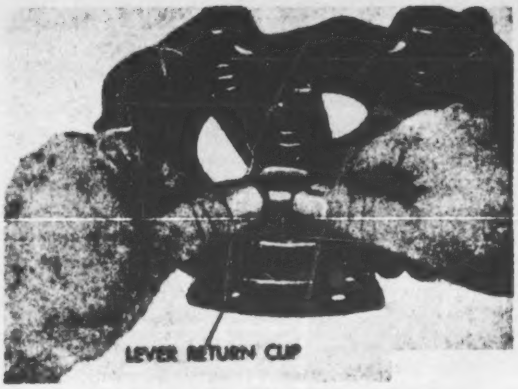
b. Examine the disk for broken disk segments, loose or broken cover rivets, or worn splines. Examine the facings for wear, warpage, cracks, oil or grease contamination, or loose rivets. Replace the disk assembly if any of these conditions exist.

c. Examine the pressure plate for ridges, scoring, and heat checks. Examine the bracket assembly for distortion or warpage. Examine the clutch plate levers for looseness or binding. If any of the above conditions are found, replace the pressure plate assembly. Examine the flywheel surface for ridges, scoring, or heat checks. If any of these are found, the flywheel will have to be replaced.

d. The clutch pressure plate adjustment should be checked. To do this place the pressure plate assembly on the flywheel with a 6 x 6 inch gage block, 0.310 inch thick, between the flywheel and the pressure plate. Install and evenly tighten the pressure plate assembly mounting bolts. Torque the bolts to 20 to 25 lb-ft. By using a depth gage, measure the distance from the top surface of the clutch pressure lever to the top surface of the gage block. This distance should be between 1.644 and 1.618 inches.



e. If the levers require adjustment, remove the clutch lever return clip and loosen the clutch lever adjusting bolts.



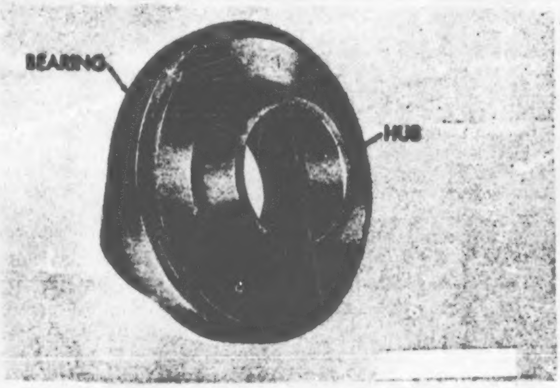
(1) Turn the clutch lever adjusting bolt until the proper measurement is obtained. Hold the adjusting bolt and tighten the adjusting bolt nut securely.

(2) Adjust all levers to the same measurement. Recheck the measurement of all of the levers, and check the adjusting bolt nuts for tightness.

(3) Install the three clutch lever return clips and remove the pressure plate from the flywheel.

f. Check the clutch pilot bearing in the bore of the flywheel. The bearing is pressed into the flywheel and should not be loose. Check the ball bearings for looseness or roughness. If the pilot bearing is damaged, it must be replaced.

g. To check the clutch release or throwout bearing, hold the hub and turn the outer race while applying pressure to it. If it feels rough or sounds noisy, replace the bearing.



h. Inspect the clutch release lever. If the lever is bent, cracked, badly worn, or the yoke springs riveted to the lever are bent or broken, replace the assembly.

11. INSTALLING THE CLUTCH ASSEMBLY. After the clutch has been inspected and the required replacement parts obtained, it can be installed by using the following procedures:

a. Place the clutch disk and pressure plate assembly in position. Install the retaining bolts and lockwashers but do not tighten them. Insert a pilot tool to aline the clutch disk and using a torque wrench tighten the bolts evenly to 15-20 lb-ft. Remove the pilot tool.

b. Position the flywheel housing and a new gasket on the engine. Install the retaining screws and torque them to 20-25 lb-ft. Slip the clutch release bearing into the clutch release levers.

c. Install the flywheel housing cover, with a new gasket, and install the retaining screws. Torque them to 8-10 lb-ft. Replace the boot seal on the release rod.

d. Position the transmission on the clutch housing. The transmission shaft must go through the release bearing, clutch disk hub, and into the pilot bearing. Install the retaining bolts and torque them to 37-42 lb-ft.

e. Install the engine and transmission as outlined in another lesson and the vehicle's -20 TM.

f. In this lesson we have covered the removal and replacement of the helical spring, single plate type clutch used in the M151, 1/4-ton truck. The same procedures with only small variations are also used to remove and replace the clutch of most other wheeled vehicles. By using the appropriate vehicle TM you should be able to replace those clutches as easily as the one on the M151.

SECTION IV. CONCLUSION

12. SUMMARY. Remember that the clutch will wear during operation. This will cause the clutch pedal free travel to change. Not enough free travel will cause the clutch to slip and burn out. Too much free travel will cause the clutch not to release as it should. This causes gear clash and hard shifting. One of the jobs of the organizational mechanic is to inspect and replace any worn or broken parts of the clutch linkage. He must also check and adjust pedal free travel. He is not usually authorized to replace the clutch.

13. PRACTICE TASKS. Appendix B of this lesson contains a list of tasks associated with wheeled vehicle clutches. They are representative of the tasks you will be required to perform as a wheeled vehicle mechanic. Perform all of the tasks listed. Be sure you are under the supervision of an officer, NCO, or specialist qualified in the MOS when you practice the tasks. If you find you are having difficulty in certain tasks, restudy the appropriate training material and practice the tasks until you become proficient in each one.

EXERCISE

Note. - Review the lesson exercise directions in lesson 1.

16. Which of the following are driving members of a clutch?

    a. Pressure plate and disk
    b. Pressure plate and flywheel
    c. Flywheel and release bearing

17. Which is an operating member of the clutch?

    a. Pressure plate
    b. Clutch disk
    c. Spring

18. What type clutch will be faster acting?

    a. Wet plate
    b. Dry plate
    c. Dry multiple disk

19. What type clutch is usually used on heavy vehicles?

    a. Single plate
    b. Double plate
    c. Multiple disk

20. What type clutch is used in the M151 1/4-ton truck?

    a. Helical spring, single plate
    b. Diaphragm spring, single plate
    c. Single coil, single plate

21. What is one advantage of a wet-type clutch?

    a. Faster acting
    b. Smoother engagement
    c. Less slippage

22. What moves the clutch release levers when the clutch is being disengaged?

    a. Pilot bearing
    b. Clutch plate
    c. Release bearing

23. Which of the following is NOT a purpose of the clutch?

   a. Connect the engine to the power train
   b. Increase torque
   c. Make shifting easier

24. To what are the driven clutch members attached?

   a. Flywheel
   b. Pressure plate
   c. Main drive pinion

25. Why are springs used in the clutch disk?

   a. To reduce clutch slippage
   b. To strengthen the disk
   c. To smooth out the power flow

26. To what are the driven disks connected in the multiple disk clutch?

   a. The clutch spider
   b. The clutch shaft
   c. The clutch case

27. What does the release fork press against when the clutch is disengaged?

   a. Release bearing
   b. Release levers
   c. Release bearing sleeve

28. The action of what spring can best be compared to the action of an oil-can?

   a. Diaphragm
   b. Coil
   c. Leaf

29. What is one thing the organizational repairman should always check for when inspecting the clutch?

   a. Warped disk
   b. Loose disk facings
   c. Worn linkage

72 30. What is used to make the clutch free travel adjustment on the M35A2 2-1/2-ton truck?

a. Shims
b. Yoke
c. Spacers

31. What can be caused by NOT enough pedal free travel?

a. Gear clash
b. Clutch drag
c. Clutch slippage

32. Clutch pedal free travel is the amount of pedal movement

a. before the clutch starts to engage.
b. after the clutch has disengaged.
c. before the clutch starts to disengage.

33. What must be done on all wheeled vehicles before the clutch can be replaced?

a. Remove the engine from the vehicle
b. Remove the transmission from the vehicle
c. Remove the transmission from the engine

34. Which wrench should be used to tighten the pressure plate retaining bolts?

a. Box end
b. Spanner
c. Torque

35. To what is clutch maintenance usually limited at organizational maintenance?

a. Pressure plate and disk replacement
b. Pressure plate adjustment and repair
c. Linkage adjustment and repair

NOTE. - QUESTIONS 36 THROUGH 40 PERTAIN TO FOLDOUT 1.

36. Which component of the clutch assembly forces the pressure plate away from the clutch disk?

    a. Clutch baffle
    b. Release lever
    c. Release fork

37. Which item disengages power developed by the engine to the wheels?

    a. Ring gear
    b. Clutch disk
    c. Flywheel

38. Which component keeps the release bearing from touching the release levers when the clutch is engaged?

    a. Clutch housing and cover assembly
    b. Release bearing pullback spring
    c. Clutch release lever and fork

39. To which item does the clutch pressure plate spring apply pressure?

    a. Flywheel
    b. Pressure plate
    c. Clutch disk

40. To what are the driving members attached?

    a. Clutch plate
    b. Clutch disk
    c. Crankshaft

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APPENDIX A

REFERENCES

TM 9-2320-218-20, w/C2	Organizational Maintenance of 1/4 Ton, 4x4, M151 Series Trucks	Sep 71
TM 9-2320-218-34, w/C1	DS and GS Maintenance Manual Truck, Utility: 1/4 Ton, 4x4, M151 Series	Jan 72
TM 9-2320-244-20, w/C1-2	Organizational Maintenance of 1-1/4 Ton, 4x4, M715 Series Trucks	Aug 71
TM 9-8000	Principles of Automotive Vehicles	Jan 56

APPENDIX B

PRACTICE TASK LIST

Practice Objective . . . . After practicing the following tasks you will be able to:

1. Inspect the clutch linkage.
2. Check the clutch pedal free travel.
3. Adjust the clutch linkage.

Note. - Select two or more types of vehicles in your unit that have conventional transmissions. Using your toolbox and a ruler, perform the following tasks.

1. Inspect the clutch linkage.
    a. Check for worn linkage.
    b. Inspect for bent or damaged linkage and missing parts.
    c. Road test to check for clutch operation.
2. Check and adjust linkage and pedal free travel.
    a. Use a ruler to measure pedal free travel.
    b. Disconnect the adjustable yoke and shorten or lengthen the clutch rod, as required, by turning the adjustable yoke.
    c. Reconnect the yoke and again check pedal free travel. Continue this until the proper free travel is obtained.

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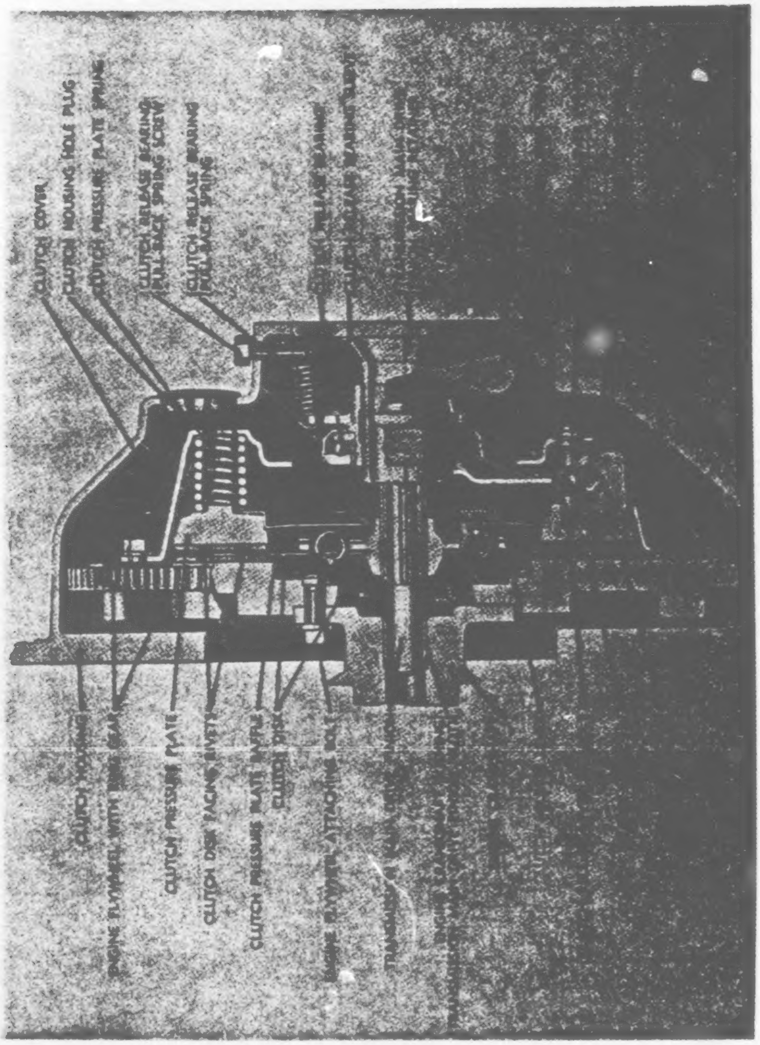
CLUTCH COVER
CLUTCH HOUSING HOLE PLUG
CLUTCH PRESSURE PLATE SPRING
CLUTCH RELEASE BEARING PULL-BACK SPRING SCREW
CLUTCH RELEASE BEARING PULL-BACK SPRING
CLUTCH RELEASE BEARING
CLUTCH RELEASE BEARING SLEEVE
CLUTCH HOUSING
ENGINE FLYWHEEL WITH RING GEAR
CLUTCH PRESSURE PLATE
CLUTCH DISK FACING RIVETS
CLUTCH PRESSURE PLATE BAFFLE
CLUTCH DISK
ENGINE FLYWHEEL ATTACHING BOLT

Foldout 1

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ENLISTED MOS

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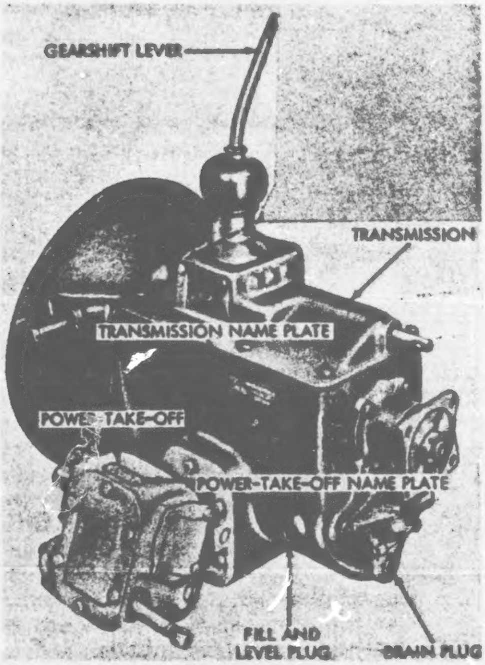
ORDNANCE SUBCOURSE 63B205



LESSON 3
FUNDAMENTALS OF CONVENTIONAL TRANSMISSIONS AND POWER TAKEOFFS

OCTOBER 1975

DEPARTMENT OF ARMY WIDE TRAINING SUPPORT
US ARMY ORDNANCE CENTER AND SCHOOL
ABERDEEN PROVING GROUND, MARYLAND

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US ARMY ORDNANCE CENTER AND SCHOOL
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LESSON ASSIGNMENT SHEET

Ordnance Subcourse No 63B205. . . Wheeled Vehicle Clutches, Transmissions, and Transfers

Lesson 3. . . . . Fundamentals of Conventional Transmissions and Power Takeoffs

Credit Hours. . . . . Two

Lesson Objective. . . . . After studying this lesson you will be able to:

1. State the types of wheeled vehicle transmissions.
2. Describe the construction of wheeled vehicle transmissions.
3. Explain the operation of wheeled vehicle transmissions.
4. Describe the power flow through wheeled vehicle transmissions.
5. Explain how the transmission gears and shafts are lubricated.
6. Describe the construction of power takeoffs.
7. Explain the operation of power takeoffs.

Text 80 . . . . Study Text

Materials Required . . . . Answer sheet and response list

Suggestions . . . . Refer to the illustrations as you read the text.

STUDY TEXT

FOREWORD

The term "cruising speed" is often heard when people are speaking about aircraft operation. This is the air speed which the aircraft uses most of the time while in the air to travel the greatest distance with the least amount of fuel.

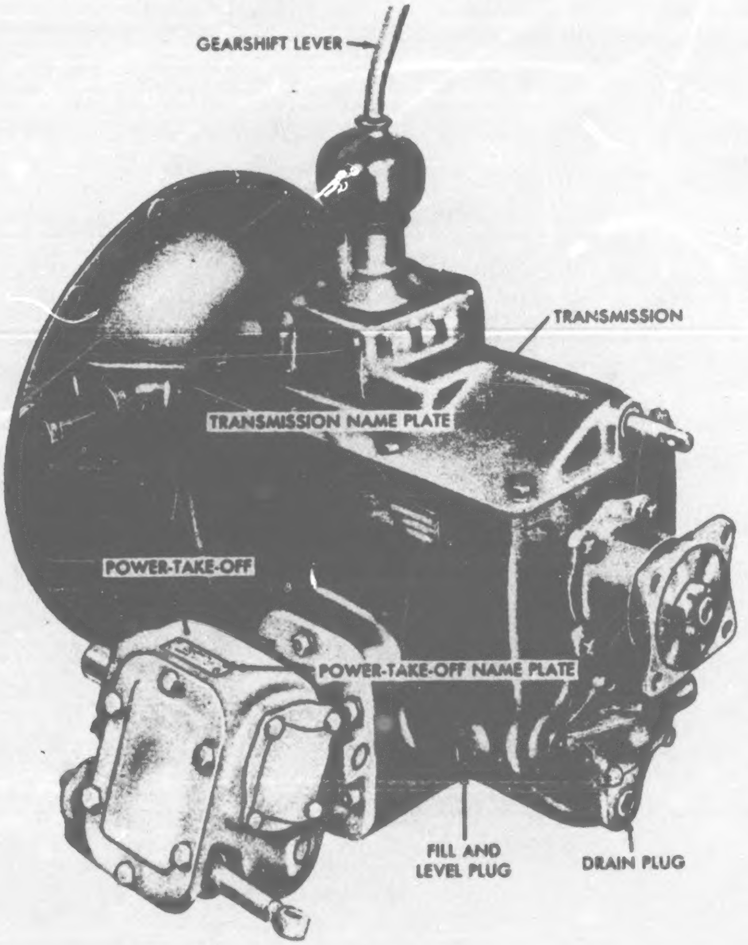
Wheeled vehicles in both civilian and military services are designed to have a cruising speed. This is obtained when the vehicle is operating on smooth hard-surface roads with the engine turning in the medium speed range. At this time the gearboxes in the power trains are in the highest speed range, which in most vehicles is direct drive from the engine to the rear axle assembly.

You have probably noticed a truck inch along as it pulled a heavy load up a long steep hill. In this instance, the engine does not have enough power to keep the vehicle moving at its cruising speed. Yet, as you can tell by its sound, the engine is still running as fast or faster than it does at cruising speed in order to produce full power. The ability to change the relationship between vehicle speed and engine RPM is provided by the vehicle transmission. In this lesson we will investigate the fundamental principles of gearboxes, such as the transmission and power takeoff.

SECTION I. TRANSMISSIONS

1. GENERAL. When a vehicle is standing still a large amount of power is required to start it moving. If the vehicle is in motion a large amount of effort is not needed to keep it in motion. This is because a vehicle that is moving will tend to stay in motion, and a vehicle that is standing still tends to remain still. The vehicle engine has enough power or turning force to keep a vehicle moving on a good road, but to move from a standing stop more power is needed. More power is also needed when operating the vehicle off the road on rough ground and when climbing steep hills.

a. To obtain the power needed so the driver can keep the vehicle operating properly under all conditions, a transmission is installed in the vehicle. At the present time most military wheeled vehicles use what is called a conventional-type transmission. This transmission provides the operator with a group of gear ratios that will increase the engine turning power to meet all road conditions.

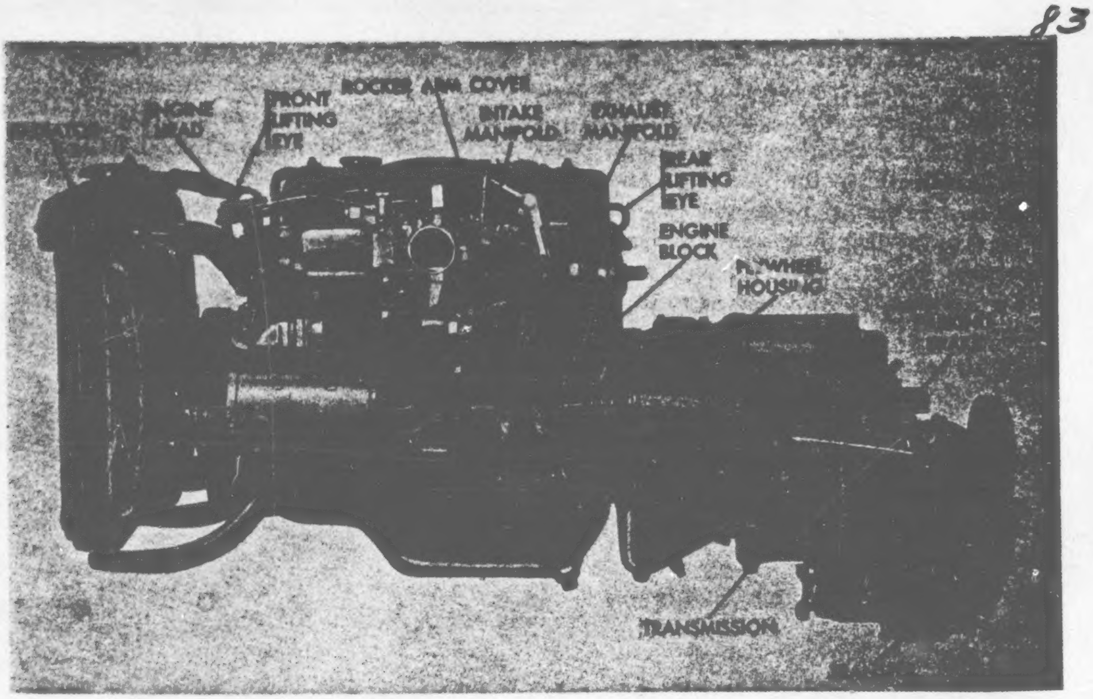


82 (1) Since the engine does not deliver enough power at low speeds, the operator must place the gears of the transmission in a gear ratio that will keep the vehicle moving with the engine speed in the medium ranges. Forcing the vehicle to pull a load at a low engine speed is called "lugging the engine," which results in engine wear and possible damage.

(2) A means must also be provided to permit the operator to move the vehicle in reverse. You cannot make the engine run backward, so the transmission must provide a means of reversing the engine power output with gears.

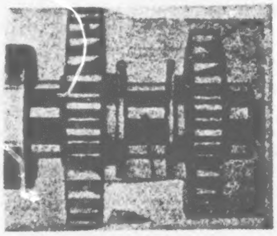
b. The transmission receives the twisting effort or torque of the engine and either increases it with gears or passes it through directly. Each shift position, except direct drive or overdrive, will provide an increase in the torque delivered by the engine. The shift positions are called transmission speeds or ratios. The number of speeds and size of a transmission will depend upon the size and type of vehicle. For example, the transmission of the military 1/4-ton truck, model M151, has four speeds forward and a single reverse. A commercial sedan, which is a small vehicle with a powerful engine, may have a transmission that has only three speeds forward and a single reverse. Large truck tractor-type vehicles sometimes have transmissions that provide fifteen speeds forward and three reverse speeds.

c. It is possible to mount the transmission in several different locations, but on most wheeled vehicles it is bolted to the rear of the engine. This construction makes a single solid unit of the engine, clutch, and transmission. The transmission on some vehicles is supported entirely by the flywheel housing of the engine. Another means of supporting the transmission is to provide mounts on the transmission housing assembly. This supports the transmission and also acts as a rear engine support. Rubber pads on the mounting surfaces aid in preventing engine and transmission vibration and noise from being sent to the vehicle body.

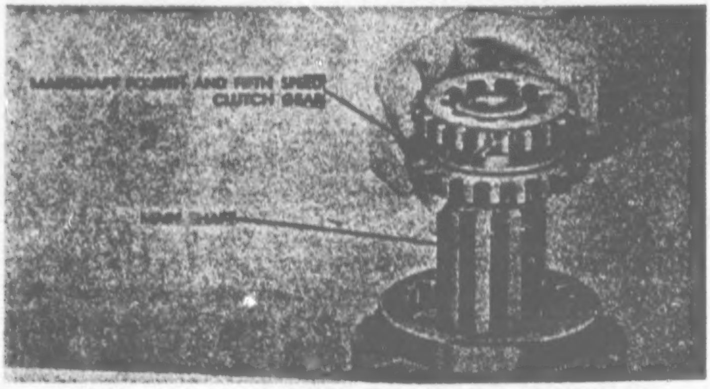


2. TYPES OF TRANSMISSIONS. There are two types of conventional, selective speed transmissions that are used in wheeled vehicles. These are the sliding gear and the constant mesh types.

a. The sliding gear was the first type used. The speeds of the transmission were obtained by sliding gears, that were mounted on a splined main shaft, forward or rearward to mesh with other gears. The splined shaft contained grooves running lengthwise that allowed the gears to slide back and forth freely. When the gear turned, the shaft was forced to turn at the same speed. These early sliding gear transmissions used straight spur tooth gears that made shifting between speeds very hard. Also, the straight spur tooth gears were noisy in operation.



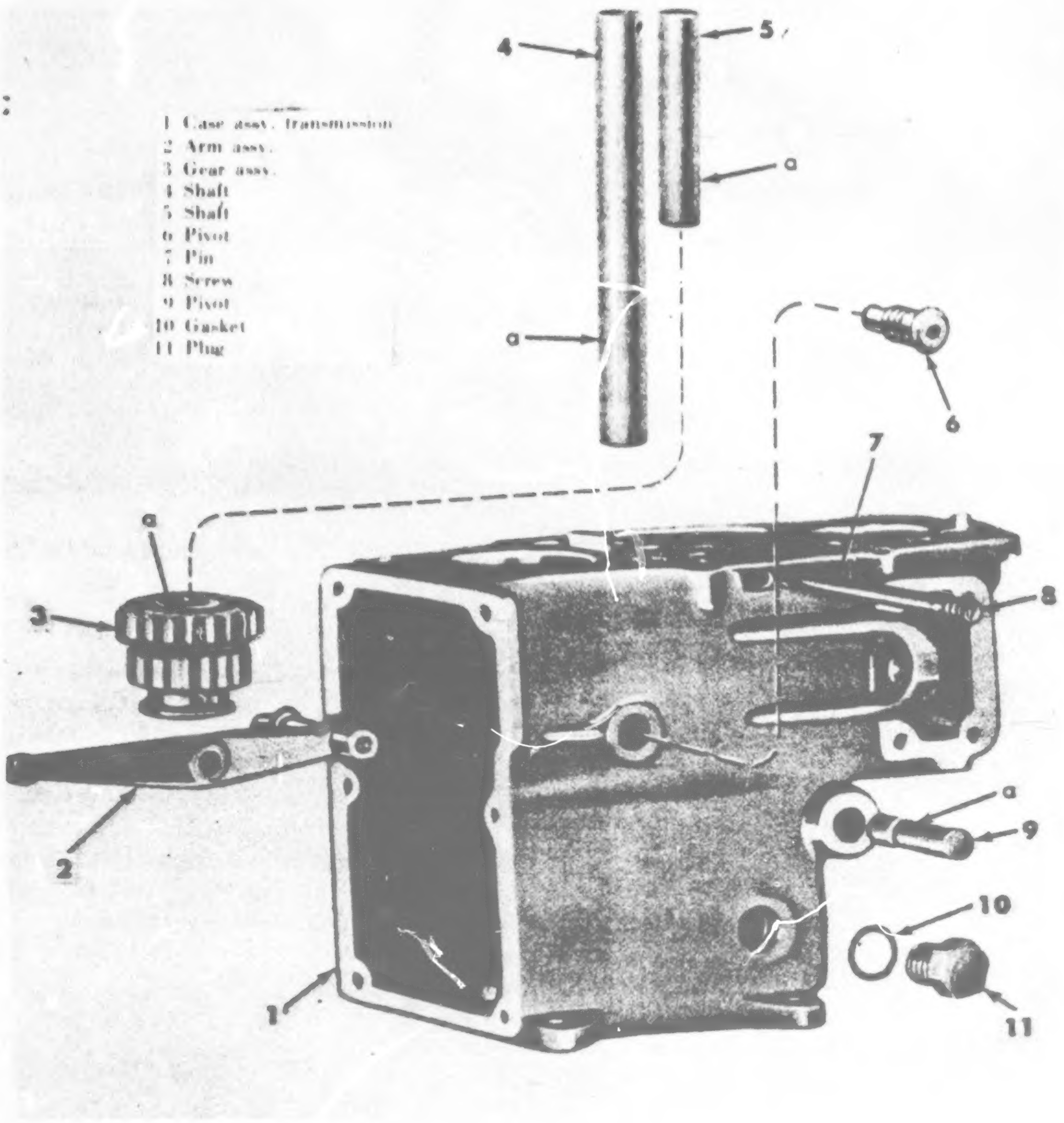
b. The constant mesh transmission is better than the sliding gear transmission because the major working gears are always in mesh and the shifting is done with gear clutches. A gear clutch consists of an external gear with the teeth on the outside that mesh with a matching internal gear that has teeth on the inside. The gear clutch shifts into mesh much easier than two external tooth gears. Shifting into various ratios was made much better by adding a synchronizer assembly to the constant mesh transmission. The synchronizer adds a small friction clutch to the sliding gear clutch of the constant mesh transmission. This clutch forces the two gears to rotate at the same speed before the teeth mesh so that the shift is made without gear noise. Presently, conventional transmission in military vehicles use some of the features of each of the two types.



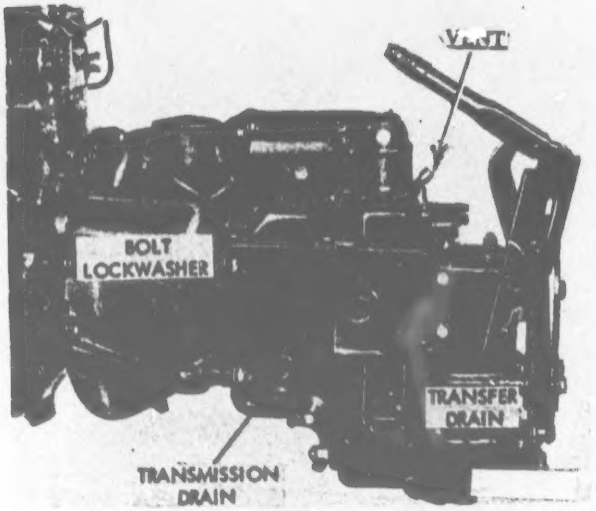
3. CONSTRUCTION OF TRANSMISSIONS. This lesson does not permit the discussion of each type of transmission used in military vehicles. Therefore, the construction and operation presented here are based upon a simple three-speed forward and one-speed reverse type transmission that is used in smaller wheeled vehicles. It should be kept in mind that all conventional transmissions are similar in construction, but as the vehicle becomes larger more speed ratios and heavier parts are needed.

a. The conventional transmission uses gears to increase engine torque for delivery to the wheels. These gears must be made to very exact measurements and operate quietly under hard use. Mounting of the gears must be correct to within a few thousandths of an inch.

(1) The transmission case provides a firm base in which the required shafts and gears are mounted. Most transmission cases are made of cast iron, but a few models have been made of aluminum alloy to reduce weight. Cast iron provides a strong long-lasting case that is low in cost. Some of the drawbacks of cast iron are that it breaks easily, is heavy, and not easily repaired.

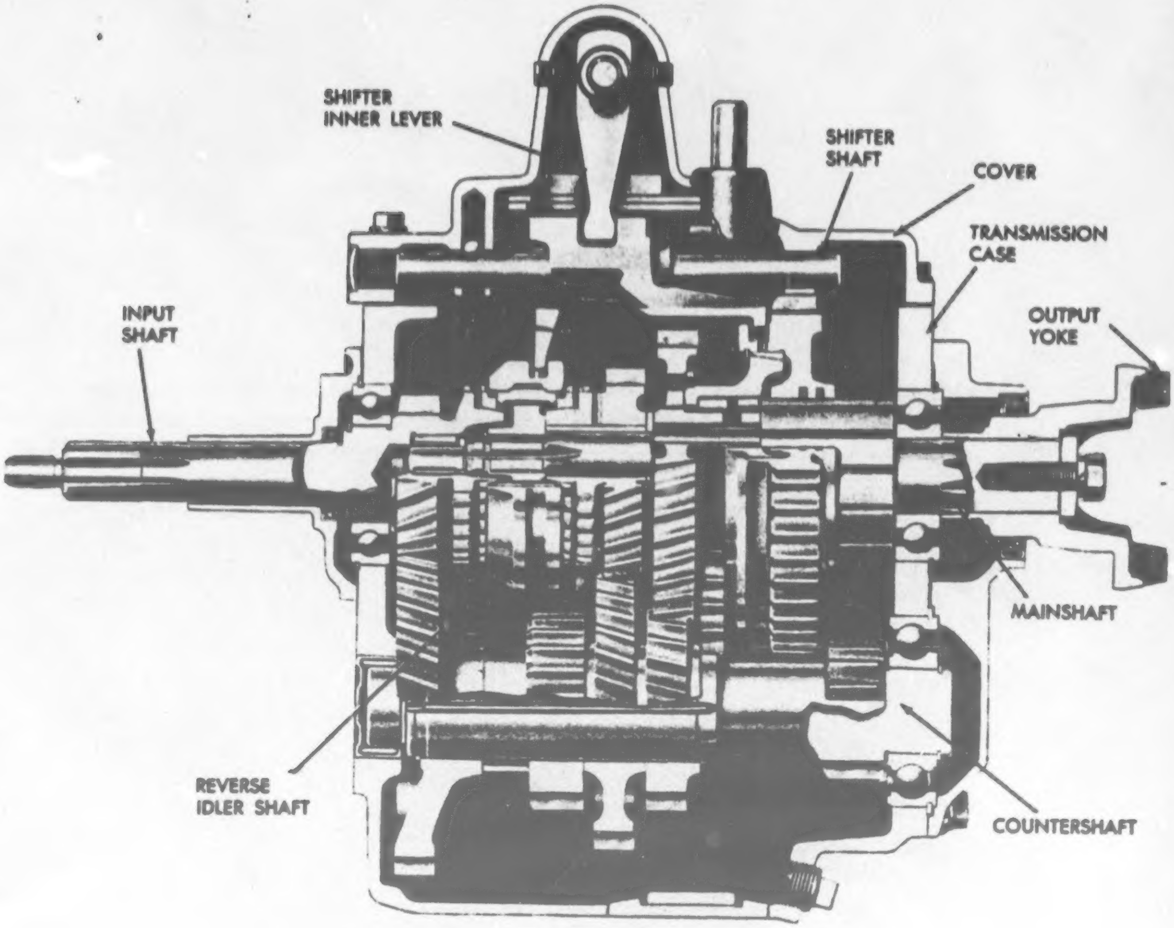


86 (2) In addition to mounting all of the inner components, the case also acts as a reservoir or storage point for the gearbox lubricating oil. Plugs in the bottom and side of the case provide a means of checking oil level or draining the lubricant. These plugs can be identified by their square-type head.

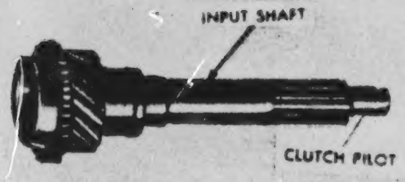


(3) The front of the case is machined to a smooth surface to match the mounting surface at the rear of the engine flywheel housing. On some models, the front of the transmission contains a bell shaped housing that becomes the rear of the flywheel housing. On most military transmissions, openings and mounting surfaces are made on the right and left sides of the case to allow for attaching additional gearboxes called power takeoffs. When not used, metal plates are bolted over the openings to seal the transmission case. Openings in the front and rear of the case are machined to a smooth finish to provide an accurate mounting for shaft bearings. The top of the case is open with smooth machined edges and threaded mounting holes for the cover assembly.

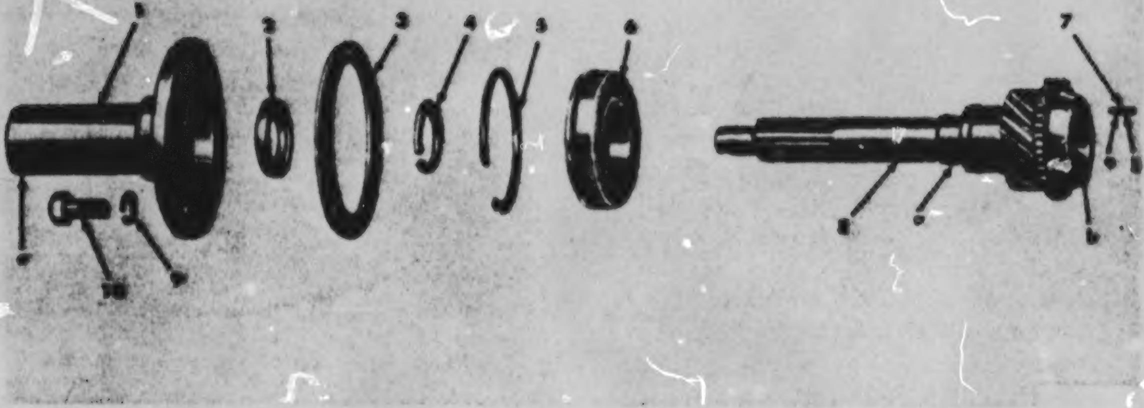
b. Inside the transmission case there are three shafts, all parallel to each other. In the upper part of the case, directly in line with and to the rear of the center of the engine crankshaft, are the input and main shafts. Directly below the input and main shafts is the countershaft. The reverse idler shaft is a short shaft that is mounted off to one side of the main shaft and the countershaft.



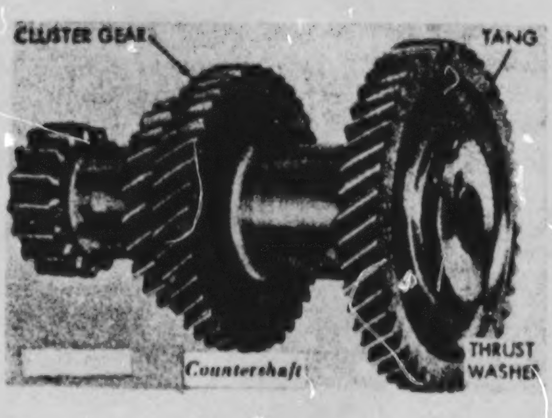
88 (1) At the front of the input shaft is a small part of the shaft called the pilot. The pilot fits into the pilot bearing in the center of the engine flywheel and supports the front of the input shaft. Just to the rear of the pilot is a splined area on the shaft. The clutch driven disk mounts on this spline and provides the connection between the transmission and engine. To the rear of the spline is a long smooth area of shaft that ends at a gear. This is the input drive gear that will be just inside the front of the transmission case when the shaft is mounted in position. To the rear of the input gear is another gear that will normally be of slightly different size than the input gear. This is the external gear portion of a synchronizer gear clutch. Both of the above gears are made as a part of the shaft. The rear of the input shaft is hollow. A smooth round opening is machined into the rear of the shaft to mount a roller bearing. This bearing supports the front of the main shaft. The input shaft is supported in the proper position by a bearing at the front of the case.



(2) Most transmissions use a large ball bearing to support the input shaft. The bearing is pressed onto the input shaft, and snaprings insure that the bearing stays in the proper position on the shaft and in the case. A bearing retainer bolted to the front of the transmission case holds the input shaft bearing in position. The bearing retainer is usually a cast iron flange with a long tube type sleeve extending forward from the center. When in position this sleeve is around but not touching the input shaft. The sleeve provides a surface to mount the clutch release bearing.



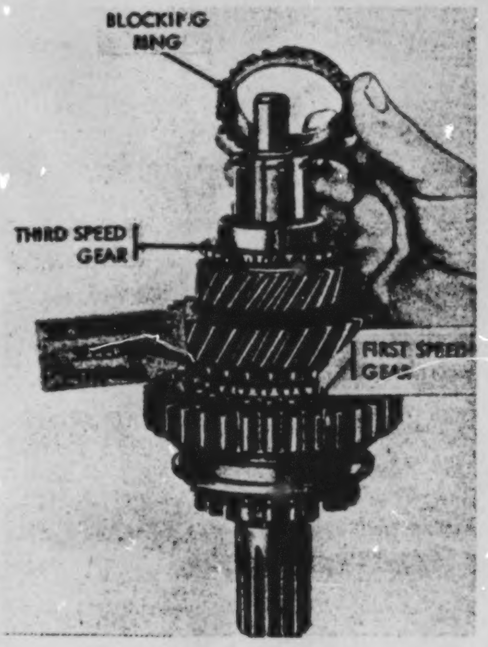
1 Retainer
2 Seal
3 Gasket
4 Snapring
5 Snapring
6 Bearing
7 Roller bearings, needle (14)
8 Shaft
9 Washer (3)
10 Screw (3)



Countershaft

(3) The countershaft is mounted directly below and in line with the transmission input and main shafts. On heavier vehicles, this countershaft assembly is a series of gears of different sizes pressed on a steel shaft. Four or more gears are used with the largest at the front. The large gear on the front of the countershaft is in mesh with the input drive gear. On some three speed transmissions, the countershaft gears from front to rear would be the drive gear, second speed, first speed, and reverse speed. Many transmissions use the same gear for both low and reverse. Countershaft bearings at the front and rear support and aline the shaft assembly within the case. On smaller transmissions the countershaft and gear may be made as two separate items. The countershaft on these transmissions is pressed into the case and held in position by a plate or

pin. This prevents the countershaft from rotating or turning. The gears are forged as a single item and mounted on the shaft with roller bearings. This allows the gear to turn while the shaft remains still. This gear sometimes is called a "cluster gear."



(4) The main shaft assembly is located to the rear and on the same center line as the input shaft. On the front of the shaft is a short pilot section that fits into the roller bearing in the rear of the input shaft. This is the front support for the main shaft. Located behind the pilot section of the shaft is a splined section that extends all the way to the rear end. Some shafts have a single size spline section while others have splines of several sizes along the main shaft. On some shafts smooth machined surfaces are located between the splined areas along the shaft. These smooth surfaces are to mount gears that are not directly connected to the shaft. The design will depend upon the manufacturer. Starting at the front of the main shaft of the simple three sliding gear transmission is the front gear which will be the second and third speed gear. This gear is mounted upon a splined part of the main shaft so that it can be moved freely forward and backward. To the rear of the second and third speed gear is the first and reverse speed gear. This is also mounted on the splined part of the main shaft. The rear of the main shaft is supported by a large bearing, usually on the ball type which is mounted in the rear of the case. A cast iron bearing retainer bolted to the rear of the case holds the bearing in position. The bearing retainer acts as a mount for an oil seal that rides against a smooth part of the main shaft. The seal prevents gear oil in the transmission case from escaping where the main shaft passes through the rear of the case. Outside the rear of the case, the main shaft has a splined and threaded section to mount a drive flange or yoke that is held in place with a large nut and cotter pin. Propeller shafts (drive shafts) connected to the flange or yoke at the rear of the transmission carry the engine power toward the rear of the vehicle. Some military vehicles have an additional gearbox called a transfer assembly bolted to the rear of the transmission case. With this type of construction the bearing retainer and drive flange are not used, since power flows directly into the transfer assembly.

4. OPERATION OF TRANSMISSIONS. Each conventional transmission uses the same method to control the gears, but the construction will vary from model to model. The control lever may be mounted in the top of the cover and come up through the floor of the vehicle cab, or the lever may be mounted under the steering wheel on the steering column.

a. Tactical military wheeled vehicles use the top cover mounted control lever. Inside the transmission the shift control parts may be mounted in the top of the transmission case or in the cover assembly.

b. Most military vehicles have the shift mechanism mounted in the transmission cover. This method of construction provides easier repair and disassembly.

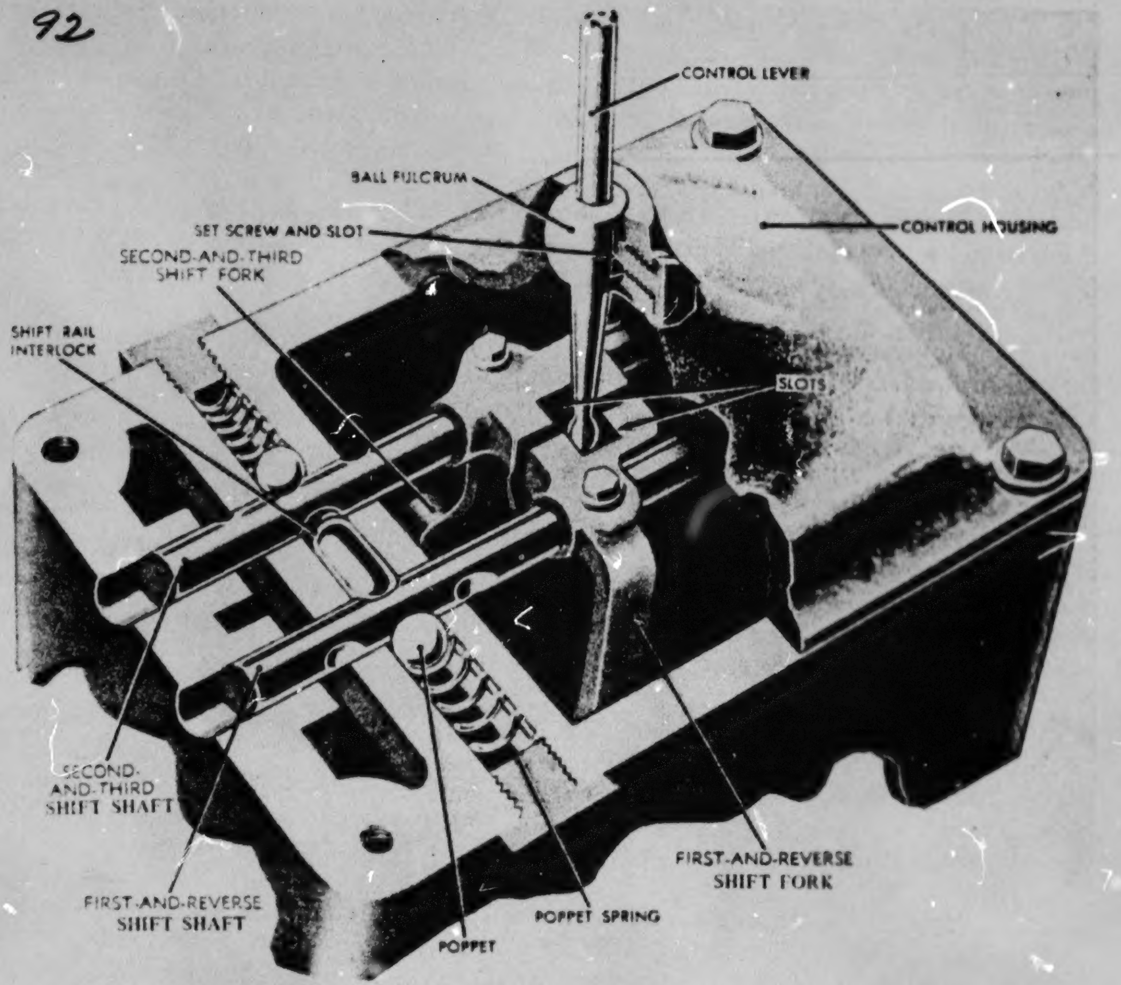
(1) Two or more shift shafts are placed in drilled passages in the cover and are in line with the main shaft. The shift shafts can move forward, backward, or stay in the center neutral position. With three positions each shift shaft can provide two transmission speeds, with the center neutral position. Most three speed forward transmissions will have two shift shafts in the control mechanism. Larger transmissions with more speeds must have additional shift shafts.

(2) To hold the shift shaft in position, poppet balls and springs are mounted in passages drilled at right angle to the shift shafts. The poppet ball spring pushes the steel ball into the detents or recesses in the shift shaft to prevent movement. Three detents are made into the side of each shift shaft, thus providing one for each shift position.

(3) Mounted on each shift shaft at the correct position is a shift fork, which is held in place by a bolt or pin. The fork extends from the shift shaft down into the case to fit into a groove made on a sliding gear. At the top of the shift fork is a slot made to receive the lower end control lever.

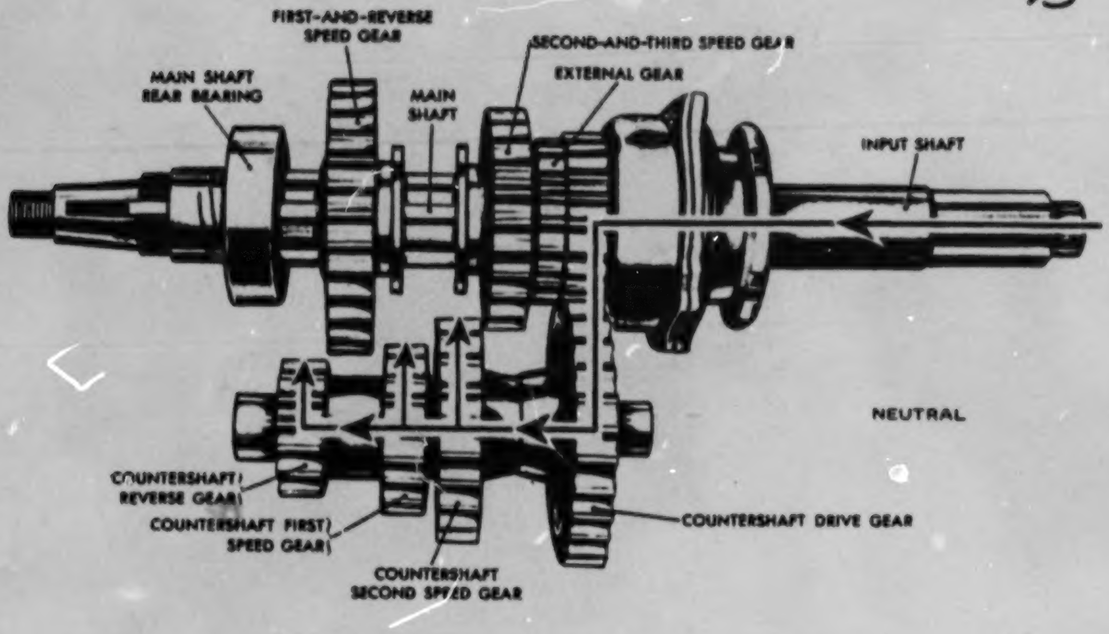
(4) The control lever is mounted in the transmission cover with a ball joint. The ball joint allows the control lever to be moved forward and backward or right and left. A pin at the ball joint prevents the lever from spinning in a circle. The upper part of the lever is outside of the transmission and extends into the vehicle cab.

(5) Located between the shift shafts and in line with the poppet balls and springs is an interlock plunger. The plunger is a pin with rounded ends that is as long as the distance between the shafts plus one shaft detent or recess. The interlock is able to slide sideways between the shift shafts. This interlock plunger prevents two shift shafts from being moved at the same time.


CONTROL LEVER
BALL FULCRUM
SET SCREW AND SLOT
SECOND-AND-THIRD SHIFT FORK
CONTROL HOUSING
SHIFT RAIL INTERLOCK
SLOTS
SECOND-AND-THIRD SHIFT SHAFT
FIRST-AND-REVERSE SHIFT FORK
FIRST-AND-REVERSE SHIFT SHAFT
POPPET SPRING
POPPET

5. POWER FLOW. To increase the torque delivered by the engine, the transmission depends upon the basic principle of a small gear driving a large gear. The conventional sliding gear transmission provides several speed ranges by sliding different size smaller gears in and out of mesh with larger gears. To understand the complete operation, each speed of a three speed forward and single reverse speed type transmission is presented below:

a. Neutral speed gear position and power flow are shown in this figure. Any time the clutch pedal is in the upper (released) position, the clutch is engaged. At this time the clutch disk is locked between the driving members of the clutch assembly. With the clutch disk splined to the input shaft of the transmission, there is a direct mechanical connection from the engine to the transmission.

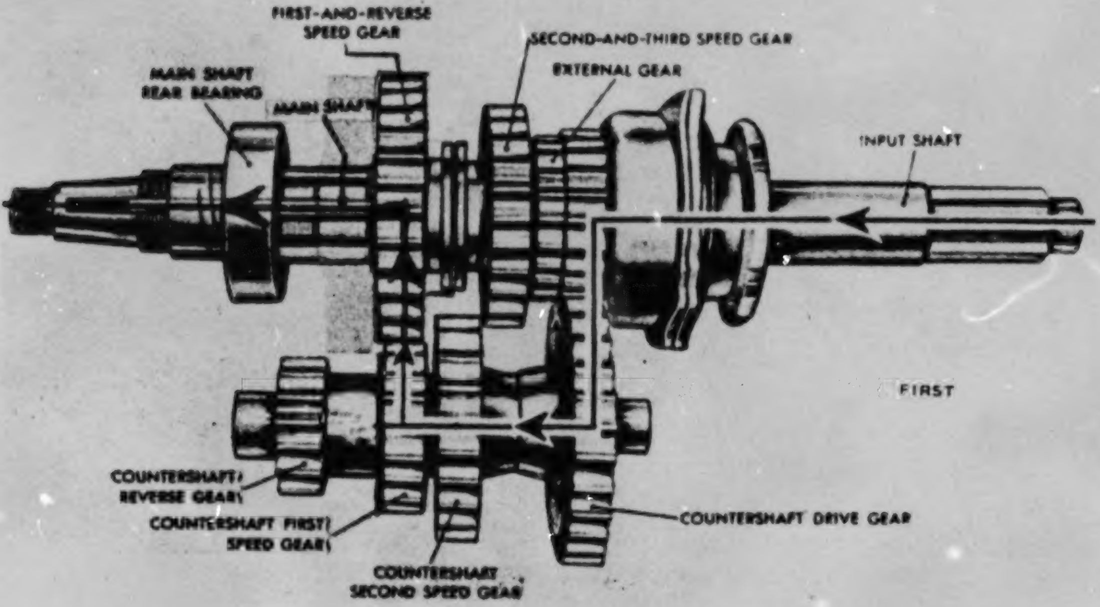

FIRST-AND-REVERSE SPEED GEAR
MAIN SHAFT REAR BEARING
MAIN SHAFT
SECOND-AND-THIRD SPEED GEAR
EXTERNAL GEAR
INPUT SHAFT
NEUTRAL
COUNTERSHAFT REVERSE GEAR
COUNTERSHAFT FIRST SPEED GEAR
COUNTERSHAFT SECOND SPEED GEAR
COUNTERSHAFT DRIVE GEAR

(1) Power flow is from the engine to the transmission input shaft which turns at the same speed as the engine. Since the countershaft drive gear is always in mesh with the input shaft main drive gear, it will also be turning but in the opposite direction from the main drive gear on the input shaft.

(2) The input gear is slightly smaller than the countershaft drive gear; therefore, the countershaft gear will turn slower than engine speed or at a reduction.

(3) The two sliding gears on the main shaft are not in mesh with any of the gears on the countershaft in neutral speed. With no main shaft gears in mesh with the countershaft gears, there is a break in the power flow path. Power flow will end at the countershaft.

94 b. First speed gear position and power flow are shown in this figure. When the vehicle operator desires to place the transmission in first speed, the first step is to release the clutch disk.

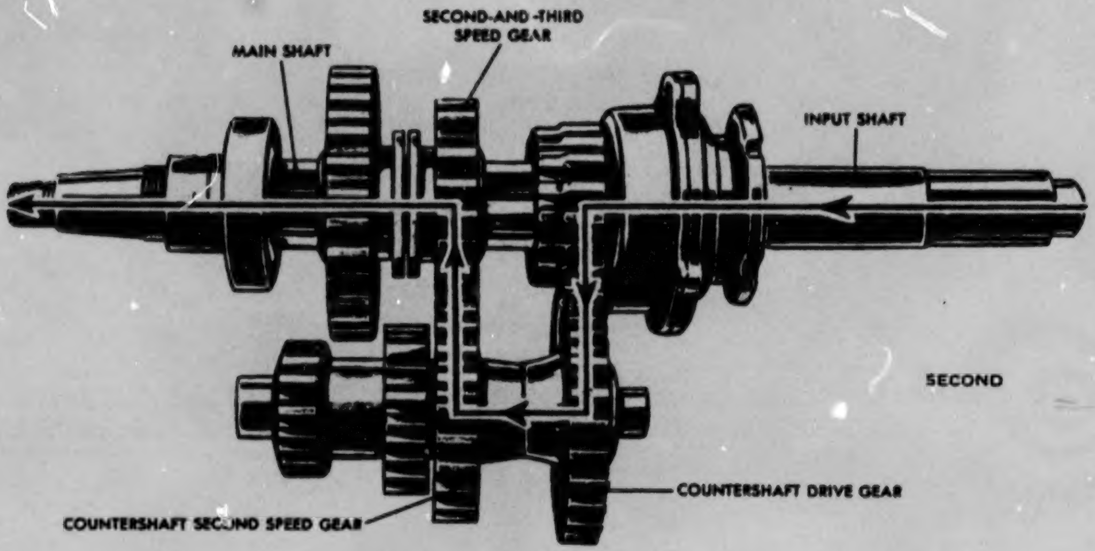

FIRST-AND-REVERSE SPEED GEAR
SECOND-AND-THIRD SPEED GEAR
EXTERNAL GEAR
MAIN SHAFT REAR BEARING
MAIN SHAFT
INPUT SHAFT
FIRST
COUNTERSHAFT REVERSE GEAR
COUNTERSHAFT FIRST SPEED GEAR
COUNTERSHAFT DRIVE GEAR
COUNTERSHAFT SECOND SPEED GEAR

(1) With the clutch pedal down and the input shaft not turning, the transmission control lever is moved into the first speed position. As the top of the control lever is moved to the rear, the bottom of the lever inside the transmission is moving forward. The lower end of the lever forces the first and reverse shift shaft, fork, and gear to move forward. The first and reverse gear slides along the spline of the main shaft and into mesh with the first speed gear on the countershaft.

(2) When the vehicle operator releases the clutch pedal, the clutch is engaged and the transmission is driven in first speed. Power flows from the engine to the input shaft, countershaft, main shaft, and out of the rear of the transmission. The small input drive gear is driving the larger countershaft drive gear; therefore, an increase in power is obtained. A second increase in power is gained with the smaller gear on the countershaft driving the larger first and reverse speed gear on the main shaft. Since the first and reverse gear is splined to the main shaft, the double increase in power is delivered to the main shaft for transmission output. The direction of rotation (turning direction) changes twice in the power path. When two external type gears are placed in mesh and turned, each will turn

in a different direction. When looking at the transmission from the front, the input shaft will be driven in a clockwise direction by the engine. This will force the countershaft to turn the opposite direction or counterclockwise. As the countershaft gear drives the gear on the main shaft, the main shaft will be forced to turn clockwise, which is the same as the input shaft.

c. Second speed gear position and power flow are shown here. The shift to second speed is normally made with the vehicle in motion or moving, and the shift is directly from first to second speed.

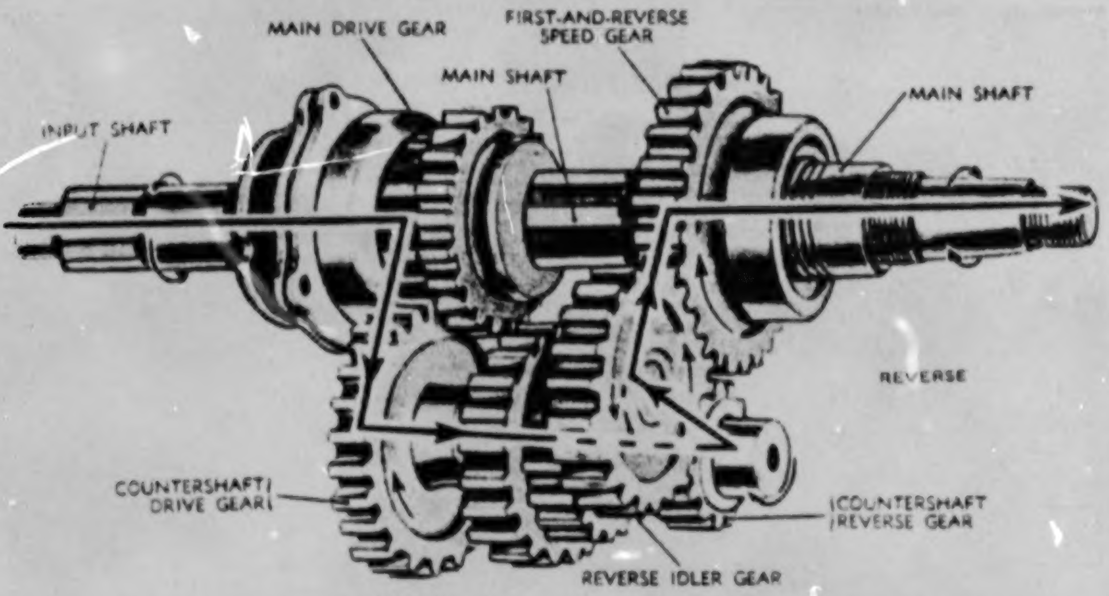


(1) In the vehicle cab, the operator releases (disengages) the clutch and moves the shift lever from the first, through neutral, and to the second speed position. Inside the transmission case, the lower end of the shift lever forces the first and reverse shift shaft fork and gear to move rearward to the neutral position. When neutral position is reached, the shift lever moves out of the first and reverse shift fork slot and sideways into the slot of the second and third speed shift fork. The second and third speed shift fork then moves to the rear. The second and third speed gear is forced to slide to the rear along the main shaft spline until it is in mesh with the second speed gear on the countershaft. When the proper position is reached, the steel poppet ball is pushed into the detent on the shift shaft by spring pressure to hold the gears in mesh.

internal teeth mesh with the external gear at the rear of the input shaft and locks the input shaft to the main shaft. The internal-type gear, inside the front of the second and third speed gear, together with the external gear on the rear of the input shaft, form a gear clutch.

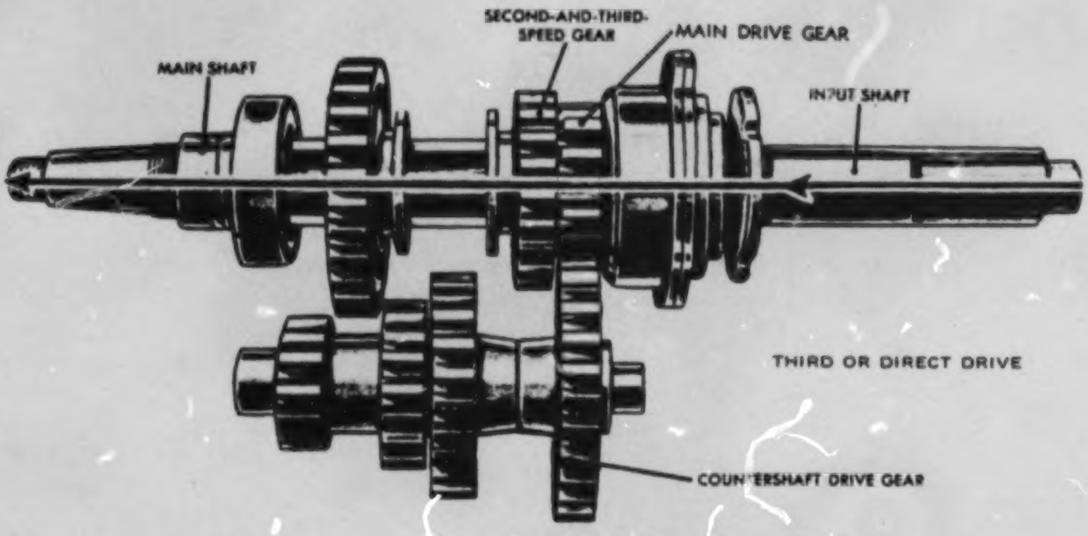
(2) With the input and main shafts locked together, power from the engine flows in the input shaft and out the main shaft when the clutch is engaged. The countershaft will be driven during this speed, but the shaft will transfer no power. In third speed, which is a direct drive in the three speed forward transmission there will be no increase in engine torque or twisting force.

e. Reverse speed gear position and power flow are shown in this figure. The wheeled vehicle should not be moving when the transmission gears are shifted from neutral to the reverse speed. The operator releases (disengages) the clutch and moves the control lever from neutral to the reverse position. The bottom of the control lever forces the first and reverse shift shaft, fork, and gear to move to the rear.



(2) The vehicle operator engages the clutch and power flows into the input shaft, countershaft, second speed gears, and out the main shaft. An increase in power is gained from the input to countershaft. There is very little difference in the size of the second speed gear on the countershaft and the second and third speed gear on the main shaft that it drives. With these gears nearly the same size there will only be a slight change in engine torque. A larger increase is not needed at the second speed gears because enough power increase is gained between the input and countershaft drive gear for the second speed. The total increase in engine torque is not as great in second speed as with first speed; therefore, output speed is greater. The power flow is into the input shaft, to the countershaft, and to the main shaft through the gearing.

d. Third speed gear position and power flow are shown in this figure. To shift the transmission from second to third speed, the vehicle operator releases (disengages) the clutch and moves the shift lever from second to third position.



THIRD OR DIRECT DRIVE

(1) As the lever moves to the rear at the top, it pivots or turns on the ball joint in the top of the cover, and the bottom of the lever moves forward inside the case. The bottom of the shift lever forces the second and third speed shift shaft, fork, and gear to move forward. As the second and third speed gear slides forward along the spline of the main shaft, it moves out of second speed, through neutral, and into third speed position. The poppet ball and spring hold the gears in the proper position. As the second and third speed gear moves forward to the third position, its

98 (1) As the first and reverse gear moves to the rear it will mesh with the reverse idler gear that is mounted to one side of the main and counter shafts. The reverse idler gear is in mesh with both the first and reverse sliding gear on the main shaft and the reverse gear on the countershaft.

(2) During all of the transmission forward speeds, the output shaft turned in the same direction as the input shaft. To drive the output shaft in the opposite direction of the input shaft, an additional gear must be placed in the gear train. This is the reverse idler gear. When looking at the transmission from the front, the input shaft turns clockwise, the countershaft turns counterclockwise, the reverse idler gear turns clockwise, and the first and reverse gear and main shaft turn counterclockwise. Each of the driving gears in this train is smaller than the driven gears, thus a larger increase in torque is gained in reverse speed. Any time a small and large gear are used to increase power in a gearbox, it is necessary to give up speed or revolutions (turns) per minute. More engine power is delivered to the vehicle wheels in reverse than in any other shift position, but the vehicle will travel slower than in forward speeds.

f. Each shift has a detent or recess in the shaft in line with the interlock plunger when in the neutral position. Recall that the interlock plunger is as long as the distance between the shift shafts plus the depth of one detent or shaft recess. When one of the shift shafts is moved from the neutral position, the recess for the interlock moves out of line with the plunger passageway. The moving shaft forces the interlock plunger to slide to the side and into the recess on the opposite shift shaft. This action locks the shaft in the neutral position. The shift shaft that was moved from neutral blocks the interlock plunger to prevent the movement of the other shaft until both shafts are once again in neutral position. When the transmission has three shift shafts, two interlocks must be used to insure that only one shaft moves at a time. This prevents the transmission from being placed in more than one gear at a time. Placing the transmission in more than one speed can cause a locked or jammed gearbox. When power is applied the gearbox could be damaged or destroyed.

6. LUBRICATION. The lower part of the transmission case contains gear oil. The amount of oil in the transmission is determined by the level plug in the side of the case. This oil in the bottom of the case covers much of the countershaft gear assembly. When the transmission is in operation and the countershaft gear is turning, oil is thrown by the gear over the entire inside of the case. Oil seals at the input and output shafts prevent oil from leaking out of the case. Some transmissions use metal plates called oil slingers in front of the shaft bearings to direct oil back to the center of the case. The lubricating oil reaches difficult places by way of drilled passages in gears and shafts.

7. VENTILATION. When a gearbox is placed into operation, the friction of the working parts generates enough heat to warm the entire item. As the component heats up, the air inside the case expands. If some means is not provided to let expanding air escape from the gearbox, a high pressure will be present in the case. Too much pressure inside the case will force the lubricating oil past the oil seals to the outside, and possibly damage the seals. A vent assembly is installed in the top of the gear cases to allow excess pressure to escape.

8. CONSTANT MESH TRANSMISSIONS. Early model sliding gear transmissions were very difficult to shift from one gear to another and were very noisy during operation. Hard shifting was improved by using constant mesh type gearing. Gears mounted on the main shaft are placed in mesh with the matching gears on the countershaft. This causes the constant mesh gears on the main shaft to be driven any time the transmission is in operation.

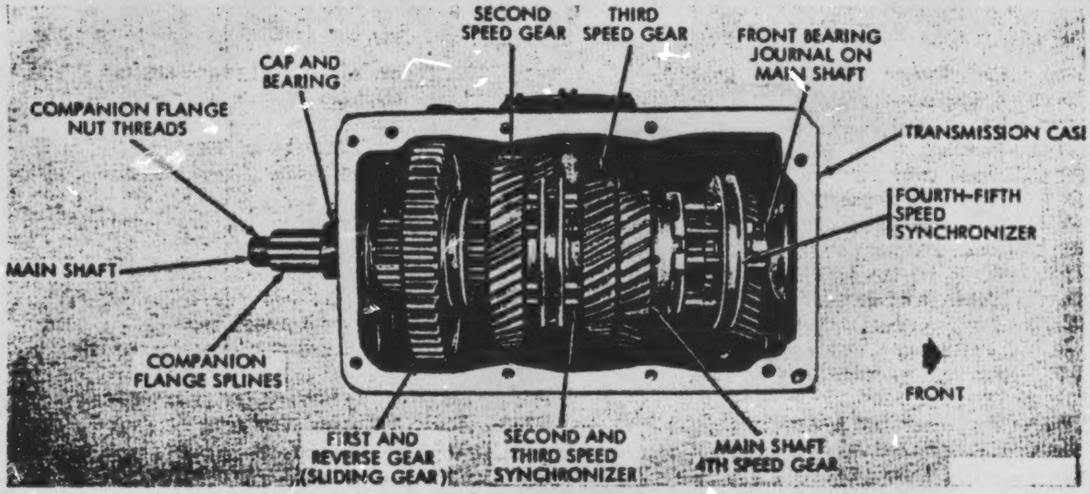
a. All of the constant mesh gears of the main shaft will have to be of the free-running type. These gears are mounted on the main shaft by means of a bearing rather than with splines. With this type of mounting there is no direct mechanical connection between the constant mesh gears and the main shaft and the gears can run free when not in use. The gears that run free on the main shaft are connected to the shaft by means of a sliding gear clutch. The sliding gear of the gear clutch is mounted on splines on the main shaft and allowed to move backward and forward.

b. When the transmission control is moved, the sliding gear moves into mesh with one of the constant mesh gears on the main shaft. This gear then drives the main shaft through the gear clutch.

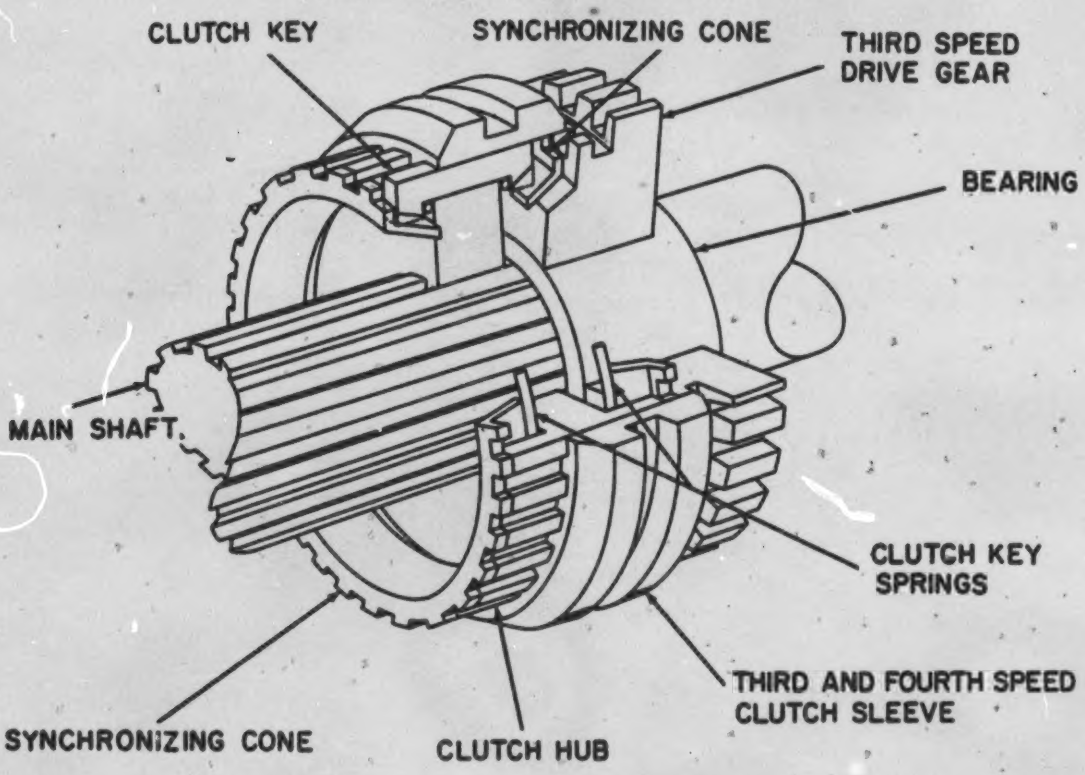
c. To reduce the noise of the moving gears during operation, helical-type gears are used in place of the straight tooth spur gears. On the helical gear, the teeth are placed on an angle across the face of the gear. This construction causes the gear teeth to slide into mesh with less noise. A disadvantage of helical-type gears is that the angle of the teeth tends to cause the gears to move endwise on their shaft which produces thrust under a load. When helical gears are used in a gearbox, thrust washers or bearings are installed to control the end thrust of the gears.

100

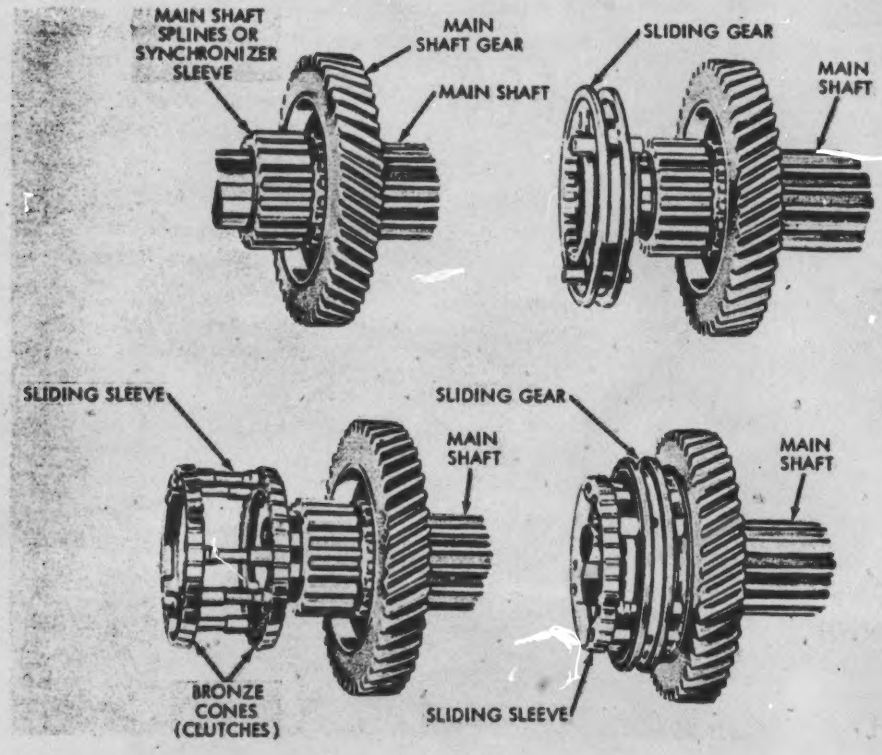
9. SYNCHROMESH TRANSMISSIONS. Hard and noisy shifting is caused by the clashing of two gears brought together while turning at different speeds. The constant mesh gear clutch type transmission improved the early sliding gear model, but there was still some shifting noise. A synchronizer assembly was added to the constant mesh type gearbox to remove all gear clash when shifting the gears.


SECOND SPEED GEAR
THIRD SPEED GEAR
FRONT BEARING JOURNAL ON MAIN SHAFT
CAP AND BEARING
COMPANION FLANGE NUT THREADS
TRANSMISSION CAS
FOURTH-FIFTH SPEED SYNCHRONIZER
MAIN SHAFT
COMPANION FLANGE SPLINES
FRONT
FIRST AND REVERSE GEAR (SLIDING GEAR)
SECOND AND THIRD SPEED SYNCHRONIZER
MAIN SHAFT 4TH SPEED GEAR

Transmission main shaft - (input shaft removed)



a. The synchronizer is a friction device which causes two gears to turn at the same speed before they are brought into mesh. When two gears are brought into mesh that are turning in the same direction at the same speed, there is no gear noise. Small cone clutches made into the synchronizer assembly are applied before the teeth of the sliding gear and the main gear come in contact. A simple synchronizer consists of a hub and sleeve. The hub is mounted on the main shaft by means of a spline that allows the assembly to move forward and backward. A sleeve is splined to the outside of the hub and is able to slide on the hub. The hub and sleeve are held together in the neutral position by detent balls under spring pressure. The detent balls and springs are mounted in passages drilled in the center of the synchronizer hub, and the balls seat in the detent or groove on the inside of the center of the sleeve. Inside of the inner edges of the hub are bronze cone clutch friction surfaces. The gears mounted to the front and rear of the synchronizer assembly have smooth steel cone surfaces that face the matching bronze cones of the synchronizer.



b. Most synchronizer assemblies are designed to operate either to the front or rear for two transmission speeds, or remain in the center position for neutral. In the neutral position, the hub is in the center of the gears to the front and rear and the sleeve is on center over the hub.

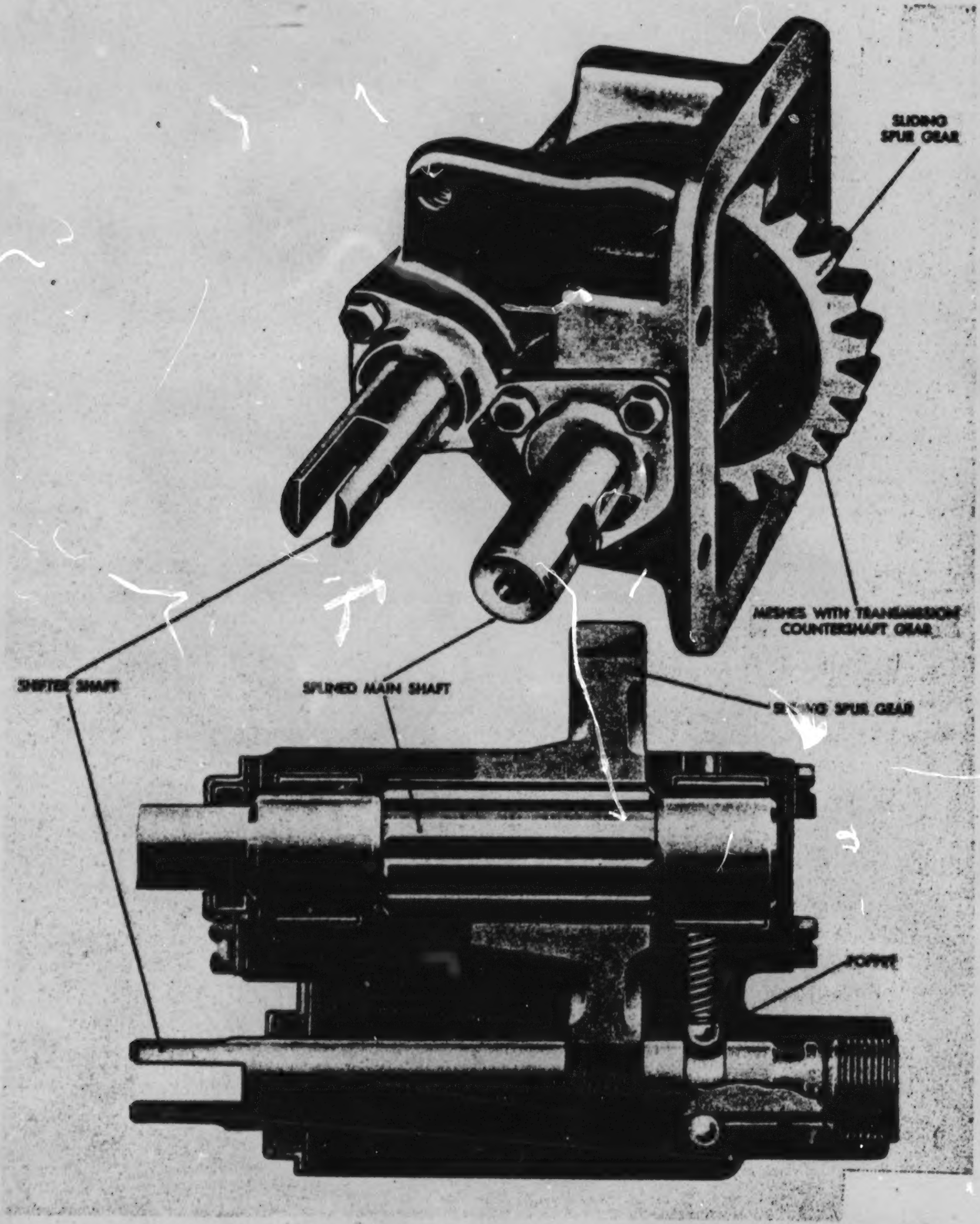
102 (1) As the vehicle operator moves the control lever, the shift shaft and fork move the synchronizer sleeve toward the gear to be engaged. With the poppet balls and springs holding the hub and sleeve together under spring pressure, the entire assembly slides toward the gear. The first part of the synchronizer to contact the gear is the bronze cone clutch surface. As the cone clutch surfaces of both the synchronizer and gear come together, the speed of the two items is made the same.

(2) The vehicle operator continues to apply pressure on the transmission control lever and the sleeve of the synchronizer is forced to override the poppet balls and slide along the top of the hub toward the gear. The sleeve slides in mesh with a small external gear made as part of the transmission constant mesh gear. This action locks the synchronizer assembly to the constant mesh gear. Power is then delivered from the constant mesh gear to the synchronizer assembly, to the main shaft, and out the rear of the transmission.

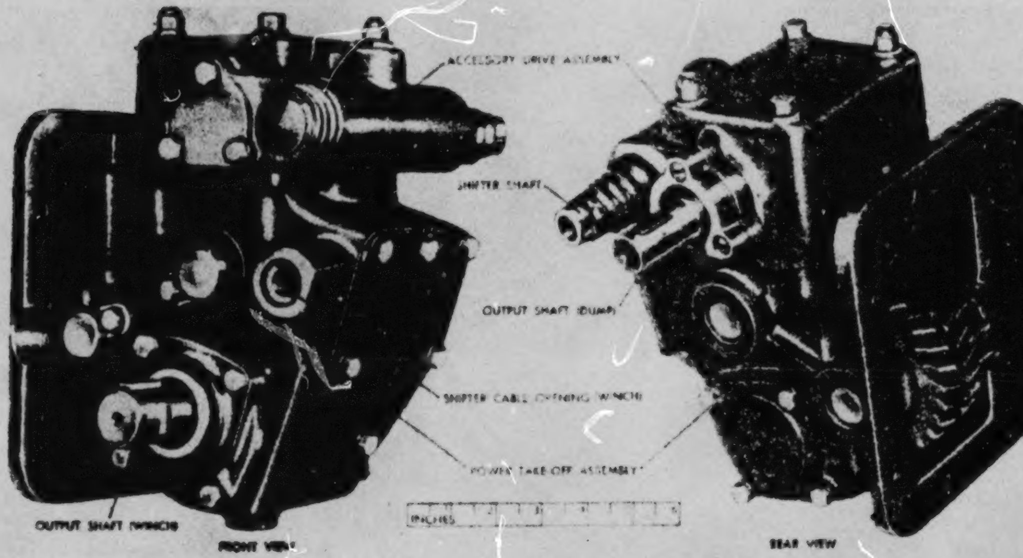
SECTION II. POWER TAKEOFF

10. GENERAL. Military vehicles often mount special equipment that is driven by the vehicle engine. Examples of these vehicles with special equipment are wreckers, dump trucks, tankers, and trucks with winches. To obtain the power to drive a winch or pump, a connection must be made into the vehicle power train. This is done with a gearbox called a power takeoff assembly. A power takeoff is bolted to a larger gearbox such as the transmission, auxiliary transmission, or transfer assembly. The power takeoff takes power from the larger gearbox as needed to drive the special equipment. Many models of power takeoff assemblies are in use on military equipment, and the size and number of speeds will depend upon the item to be driven.

a. The most simple power takeoff is the single speed, single gear type. This assembly will drive an item of special equipment in one direction at one speed.

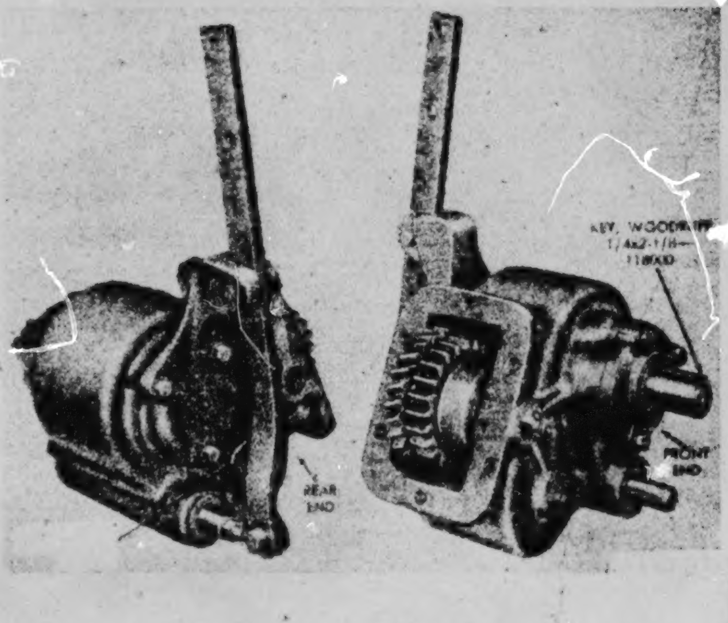


104 b. Larger power takeoff assemblies may have several forward speeds, reverse speeds, and drive two or more pieces of special equipment.

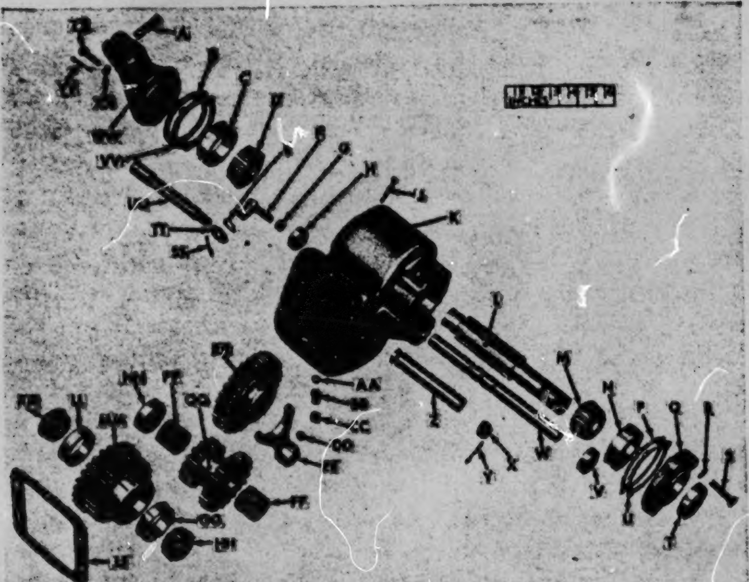


11. CONSTRUCTION AND OPERATION.

The construction and operation presented here is based on a single forward and reverse speed power takeoff for driving a vehicle front winch. This power takeoff has a forward, reverse, and neutral shift position.



a. A cast iron case provides the housing and mounting for all of the shafts and gearing of the assembly. A large flanged opening on the side of the gearbox provides the mounting surface. The mounting flange will match the mounting surface made on the side of the transmission or transfer assembly that is to mount the power takeoff. Machined openings in the front and rear of the case provide mounting points for the shafts. Some cases contain a drain plug for the lubricant.



A—PIN, CLEVIS, SHIFT LEVER—7351267
B—GASKET, DRIVE SHAFT PLATE (0.010 THK)—7351237
C—CUP, DRIVE SHAFT BEARING—706744
D—CONE, DRIVE SHAFT BEARING—705834
E—WASHER, SPG, EYE BOLT—7351139
F—BOLT, EYE, SHIFTER SHAFT, ASSY—7351238
G—NUT, 3/8-24NF—120369
H—SEAL, OIL, SHIFTER SHAFT—500012
J—RIVET, B-HD, 7/32 x 2-1/4—105098
K—HOUSING—DH-12533
L—SHAFT, DRIVE—7374906
M—CONE, DRIVE SHAFT BEARING—705834
N—CUP, DRIVE SHAFT BEARING—706744
P—GASKET, DRIVE SHAFT PLATE (0.020 THK)—7351236
Q—PLATE, RETAINING, DRIVE SHAFT OIL SEAL—7705786
R—WASHER, LOCK, 5/16 IN—120214
S—SCREW, CAP, 5/16-18NC x 3/4—122007
T—SEAL, OIL, DRIVE SHAFT—7374812
U—GASKET, DRIVE SHAFT PLATE (0.010 THK)—7351237
V—SEAL, OIL, SHIFTER SHAFT—500012
W—SHAFT, SHIFTER—7705755
X—NUT, SLOTTED, 1/2-20NF—125250
Y—PIN, COTTER, 5/32 x 1-3/4—103399
Z—SHAFT, REVERSE GEAR—7374905
AA—BALL, SHIFTER SHAFT, 7/16 IN—104921
BB—SPRING, SHIFTER SHAFT BALL—7351140
CC—PLUG, PIPE, SLOTTED, HEADLESS, 1/4 IN—113935
DD—SCREW, SET, 3/8—16NC x 7/16—139413
EE—FORK, SHIFTER—7705757
FF—BEARING, ROLLER, REVERSE GEAR—708224
GG—CUP, IDLER GEAR BEARING—707085
HH—CONE, IDLER GEAR BEARING—705369
JJ—GASKET, POWER TAKE-OFF—7351235
KK—CONE, IDLER GEAR BEARING—705369
LL—CUP, IDLER GEAR BEARING—707085
MM—GEAR, IDLER—7374902
NN—SPACER, REVERSE GEAR—DH-12535
PP—BEARING, ROLLER, REVERSE GEAR—708224
QQ—GEAR, REVERSE—7351234
RR—GEAR, SLIDING—7705756
SS—PIN, COTTER, 1/8 x 1-5/8—119209
TT—WASHER, PLAIN, 15/32, ID, 59/64 OD—120395
UU—SHAFT, IDLER GEAR—7374904
VV—GASKET, DRIVE SHAFT PLATE, (0.020 THK)—7351236
WW—PLATE, DRIVE SHAFT END—DH-6164D
XX—WASHER, LOCK, 5/16 IN—120214
YY—PIN, COTTER, 1/8 x 1-5/8—119209
ZZ—SCREW, CAP, 5/16-18NC x 3/4—122007

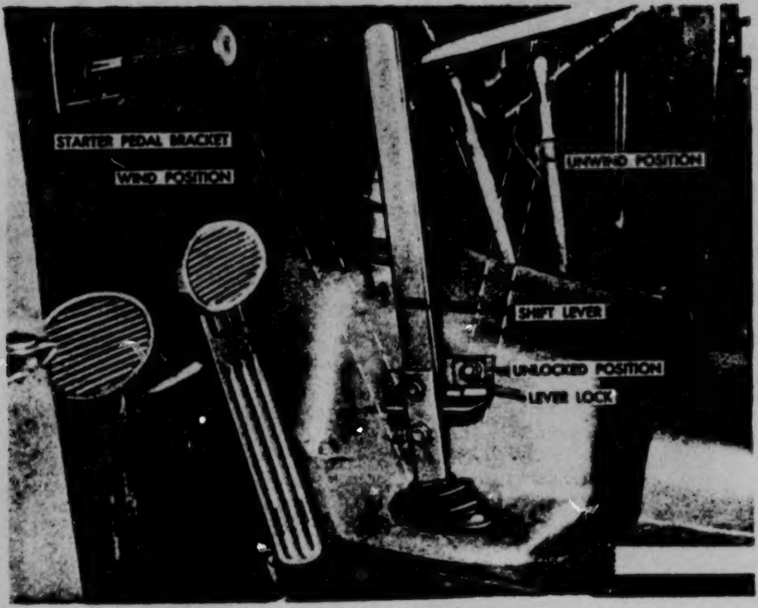
106 (1) All shafts in the gearcase are mounted in line with the vehicle power train, or from front to rear of the vehicle. Output shafts may extend outside the front or rear of the power takeoff case. Those driving the front winch will extend from the front. Tapered or straight roller bearing may be used to mount shafts in the case. Shift shafts are made to slide forward and rearward in a drilled passage in the case as in the conventional transmission. The shift fork is bolted or pinned to the shift shaft. A recess or detent is made into the shift shaft for each shift position. A steel ball under pressure is mounted in a passage at a right angle to the shift shaft and fits into the recesses.

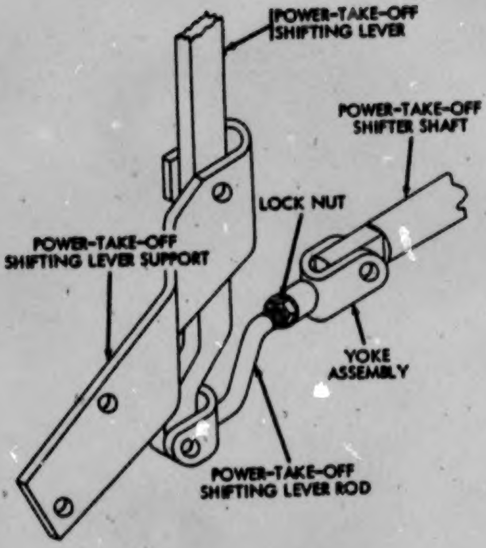
(2) The power takeoff idler gear is mounted very near the large flange on the side of the case. This method of mounting causes the idler gear to extend outside the power takeoff case. When the power takeoff is bolted to a transmission or transfer, the idler gear extends into the larger gearbox to mesh with a driving gear. The idler gear is a double gear with two sets of gear teeth. One set of gear teeth is designed to mesh with a drive gear in the transmission, and the other will mesh with the reverse gear in the power takeoff. The reverse gear is a double gear that is mounted to one side and is in constant mesh with the idler gear. Straight roller bearings are used to mount the reverse gear to the shaft. The sliding gear, which is made to mesh with both the idler reverse gears, is mounted on the spline of the output shaft. Tapered roller bearings at each end mount (support) the output shaft in the power takeoff case. The sliding gear can slide to the front or rear on the output shaft. A part of the output shaft extends to the outside of the case. An oil seal and retainer prevents loss of lubricating oil where the output shaft passes through the case. A propeller shaft drive yoke is mounted on the end of the output shaft, outside the power takeoff case, and is secured by a metal key which fits into a slot in the shaft.

b. When the power takeoff is mounted on the side of the transmission, the shift lever extends up into the cab of the vehicle.

(1) A slot cut into the cab floor allows the lever to be moved back and forth.

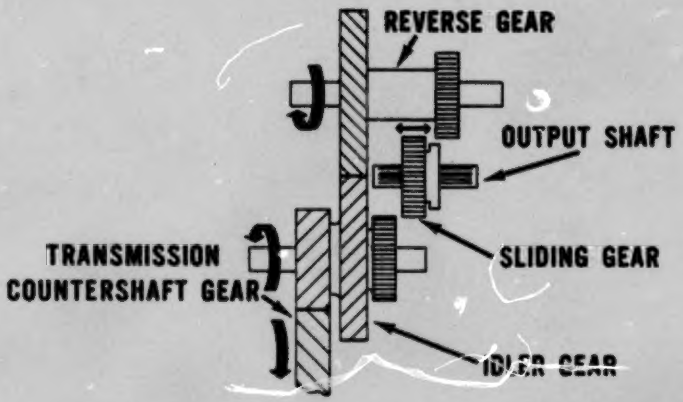
(2) A latch for holding the lever in the neutral position, when the power takeoff is not in use, is mounted to the cab floor.


STARTER PEDAL BRACKET
WIND POSITION
UNWIND POSITION
SHIFT LEVER
UNLOCKED POSITION
LEVER LOCK


POWER-TAKE-OFF SHIFTING LEVER
POWER-TAKE-OFF SHIFTER SHAFT
LOCK NUT
POWER-TAKE-OFF SHIFTING LEVER SUPPORT
YOKE ASSEMBLY
POWER-TAKE-OFF SHIFTING LEVER ROD

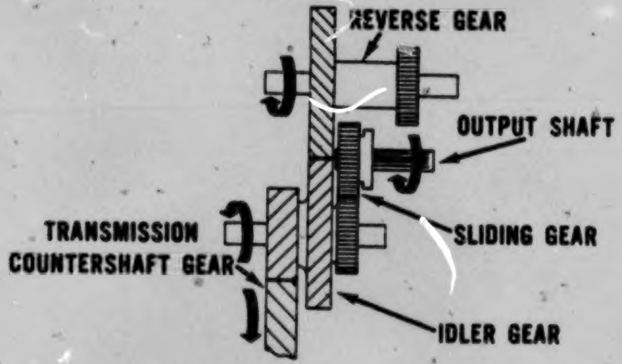
108 (3) In the neutral position, the power takeoff idler gear is in constant mesh with a gear on the transmission countershaft. The power takeoff reverse gear is in constant mesh with the idler gear. The sliding gear is in the neutral position between the idler and reverse gears. When the vehicle clutch is engaged by the operator, the transmission countershaft will drive the idler and reverse gears of the power takeoff. Since the sliding gear is not in mesh with any driving gear, no power reaches the output shaft.

POWER TAKE-OFF GEARING
(NEUTRAL POSITION)



c. Now let's see what happens when a power takeoff used to operate a winch is put into operation.

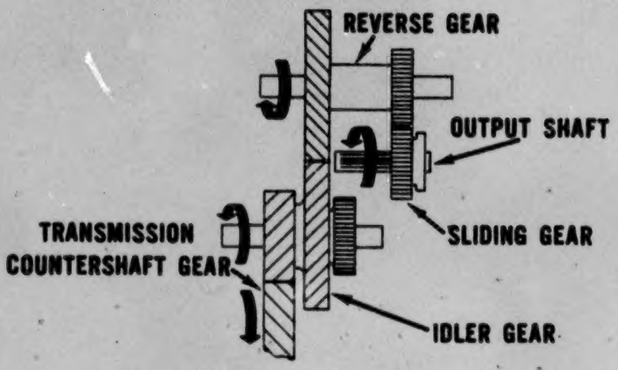
POWER TAKE-OFF GEARING
(WIND POSITION)



(1) To wind in the cable the vehicle operator releases (disengages) the clutch and moves the power takeoff control lever. As the top of the shift lever moves forward, the lever pivots on the mounting pin and the lower end of the lever moves rearward. The shift shaft, which is connected to the lower end of the control lever, moves to the rear. At the same time the shift fork mounted on the shift shaft is moving the sliding gear inside the power takeoff to the rear. The sliding gear moves along the splines of the output shaft into mesh with the idler gear. When the shift is complete, the steel ball under spring pressure moves into the recess on the shift shaft to hold the gears in position. As the engine clutch is engaged, the transmission countershaft drives the power takeoff idler gear, sliding gear, and output shaft. The output shaft drives the winch propeller shaft in the proper direction to cause the winch to wind in the cable.

(2) In order to drive the winch so that the cable will unwind from the drum, the vehicle operator releases the engine clutch and moves the power takeoff control lever to the rear. This forces the shift shaft, fork, and sliding gear to move forward so that the gear meshes with the reverse gear. The steel ball under spring pressure holds the shift shaft in the selected position. As the engine clutch is engaged, the transmission countershaft drives the idler, reverse, and sliding gears. Since the sliding gear is splined to the output shaft, the shaft is driven in the same direction as the gear. The winch propeller shaft is driven by the output shaft in the proper direction to unwind the cable from the winch drum.

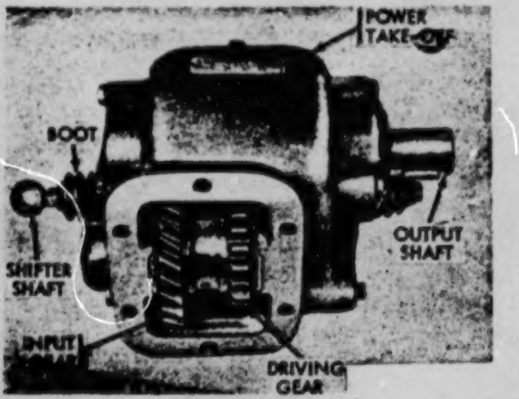
POWER TAKE-OFF GEARING
(UNWIND POSITION)



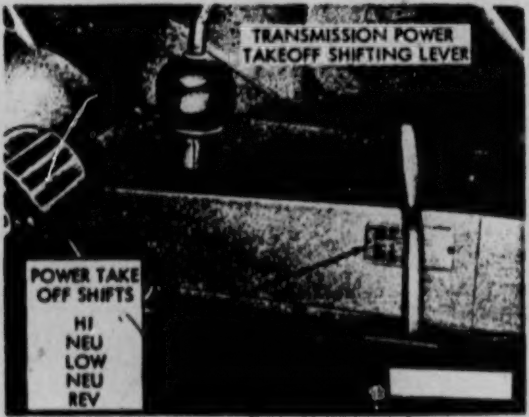
d. Power takeoff assemblies mounted low on the side of a larger gearbox are below the level of the lubricating oil. This construction allows the transmission lubricant to flow freely in and out of the power takeoff. Proper lubrication is assured for all power takeoff parts in operation below the level of the gear oil. On those power takeoff assemblies mounted above the level of the lubricant, oil is splashed into the assembly by the transmission countershaft.

110e. The heavy-duty type power takeoff is designed to mount on a standard 6-hole or 6-stud power takeoff opening. The unit is designed to mount on left or right side of the driving mechanism. The shifter shaft extends through each end of the case so that the shifting control linkage may be attached at either end. The output shaft extends from the front of the case and is provided with a woodruff key for mounting the winch propeller shaft companion flange. Boots are installed over the ends of the shifter shaft to protect the surface of the shaft. The input gear of the power takeoff is a cluster composed of a helical gear, which is constantly in mesh with the helical gear of the transmission reverse idler gear, and the driving gear, which is of spur tooth construction. The power takeoff has two speeds forward, neutral, and one speed in reverse. A shifting mechanism provides selection of the desired speed and direction of rotation of the output shaft. The neutral position of the shifting mechanism disengages the output shaft gears from the driving gear.

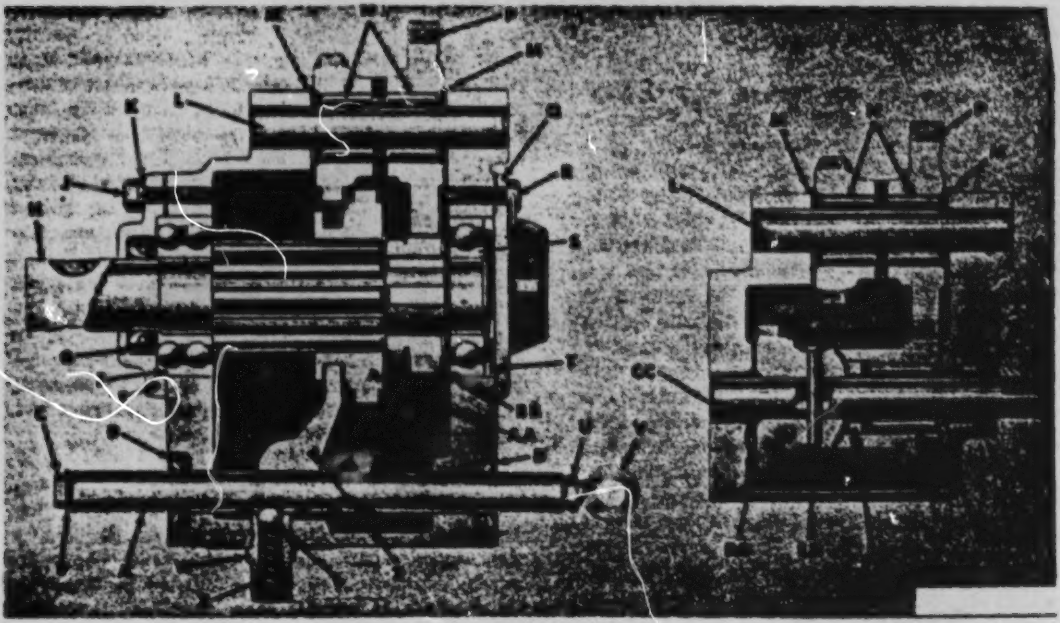
Transmission power takeoff with accessory drive.



Power takeoff.



Note. - The reference letters in parentheses pertain to the following figure.



Key	Item	Key	Item
A	Shifter shaft	T	Output shaft rear bearing spacer
B	Plain washer	U	Hex-nut
C	Capscrew	V	Eyebolt
D	Shifter shaft oil seal	W	Retainer
E	Output shaft front bearing cap	X	Spring
F	Output shaft front bearing	Y	Ball
G	Output shaft oil seal	Z	Fork
H	Output shaft	AA	Output shaft sliding gear
J	Capscrew	BB	Output shaft high speed gear
K	Lockwasher	CC	Reverse gearshaft front bearing
L	Input gearshaft	DD	Reverse gear thrust washer
M	Input gear thrust washer	EE	Reverse gear pin
N	Input gear roller bearings	FF	Reverse gear
P	Input gear	GG	Reverse gearshaft needle bearing
Q	Output shaft rear bearing cap	HH	Reverse gearshaft rear bearing
R	Capscrew	JJ	Reverse gearshaft
S	Output shaft rear bearing		

(1) Input gear. The helical input gear is in constant mesh with the helical gear of the transmission reverse idler gear and therefore is in constant rotation when the engine is engaged. The input gear (P) is installed on a nonrotating input gearshaft (L) and is mounted on the input gear roller bearings (N). The shaft is pressed into the housing and secured with a cotter pin. A thrust washer (M) is located at each end of the input gear. The

helical tooth portion of the input gear is in constant mesh with the reverse gear (FF) which is installed on the reverse gearshaft (JJ) and secured with the reverse gear pin (EE). The reverse gearshaft rotates in two supporting roller bearings (GG).

(2) Output shaft. The output shaft (H) is supported in the housing on two ball bearings. Two gears are installed on the output shaft. One is the output shaft sliding gear (AA) which is moved forward and backward on the shaft by the shifter fork (Z). The other is the output shaft high speed gear (BB) which is free on the output shaft and is in constant mesh with the input gear. The sliding gear (AA) is splined to the output shaft and may mesh with the reverse gear spur teeth, with the spur teeth on the input gear for low speed operation, or it may act as a clutch gear to couple the output shaft high speed gear to the output shaft.

(3) Shifter fork. The shifter fork (Z) is attached to the shifter shaft (A) by means of a capscrew. The fork engages the circumferential groove on the sliding gear.

SECTION III. CONCLUSION

12. SUMMARY. In this lesson we have discussed the construction and operation of transmissions and power takeoffs. The knowledge you gain here will prove to be very useful during the next lesson, which is on the maintenance of the above gearboxes.

13. PRACTICE TASKS. Appendix B of this lesson contains a list of tasks associated with transmissions and power takeoffs. They are representative of the tasks you will be required to perform as a wheeled vehicle mechanic. Perform all of the tasks listed. Be sure you are under the supervision of an officer, NCO, or specialist qualified in the MOS when you practice the tasks. If you find you are having difficulty in certain tasks, restudy the appropriate training material and practice the tasks until you become proficient in each one.

EXERCISE

Note. - Answer the following questions before continuing to lesson 4.

41. What is a disadvantage of cast iron gearbox cases?

    a. Hard to repair
    b. Light in weight
    c. High in cost

42. Where is the front of the transmission input shaft mounted?

    a. Front of flywheel housing
    b. Rear of case
    c. Center of flywheel

43. How is the sliding gear of a power takeoff mounted?

    a. On a bronze bushing
    b. On a straight roller bearing
    c. On a splined shaft

44. What prevents loss of gear oil around shafts that protrude out of the transmission case?

    a. Oil slinger
    b. Oil seal
    c. Gasket

45. What transmission shaft controls movement of the sliding gears?

    a. Main
    b. Shift
    c. Counter

46. Where is the power takeoff mounted on the conventional transmission case?

    a. Side
    b. Rear
    c. Top

47. What is used in a synchronizer to make the two meshing gears rotate at the same speed?

    a. Disk clutch
    b. Centrifugal clutch
    c. Cone clutch

48. What type of gears is used in the conventional transmission to make it quieter?

a. Bevel
b. Straight spur
c. Helical

49. How many shift positions will a power takeoff normally have to operate a winch?

a. One
b. Two
c. Three

50. Where is a conventional transmission mounted on a wheeled vehicle?

a. Rear of transfer assembly
b. Rear of engine
c. Front of engine

51. What is used in the transmission control mechanism to hold the shift shaft in the selected position?

a. Control lever
b. Interlock plunger
c. Poppet ball and spring

52. What metal is used most often to construct the case or housing of a power takeoff?

a. Cold rolled steel
b. Cast iron
c. Forged steel

53. What is true of the countershaft of a conventional transmission in neutral speed with the engine clutch engaged?

a. Will not turn
b. Turns faster than the input shaft
c. Turns in the opposite direction of the input shaft

54. What type of clutch is used to connect gears to the main shaft on the constant mesh transmission?

   a. Friction disk
   b. Cone
   c. Sliding gear

55. What part of the conventional transmission prevents shifting into two speeds at the same time?

   a. Interlock
   b. Poppet ball
   c. Synchronizer

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APPENDIX A

REFERENCES

TM 9-2320-209-20, w/C1-6	Organizational Maintenance of 2-1/2-Ton, 6x6, M34, M35, and M36 Series Trucks	Apr 65
TM 9-2320-218-20, w/C2	Organizational Maintenance of 1/4-Ton, 4x4, M151 Series Trucks	Sep 71
TM 9-8000	Principles of Automotive Vehicles	Jan 56
TM 9-8024, w/C3, 5-7	Organizational Maintenance of GMC Series, 2-1/2-Ton, 6x6, Trucks	Oct 55

APPENDIX B

PRACTICE TASK LIST

Practice Objective. . . . . After practicing the following tasks you will be able to:

1. Locate the transmission on a vehicle.
2. Identify the major components of a transmission.
3. Locate the power takeoff on a vehicle.
4. Trace the power flow in each speed range of a transmission.

1. Using vehicles in your unit, do the following:

a. Locate and identify the type of mounting on each.

b. Determine the shifting pattern of each and practice selection of the various speed ranges.

c. Locate the power takeoff on the vehicles and trace its drive line to the unit it drives.

2. Visit your support maintenance unit and inspect a transmission with the cover off.

a. Identify the following:

(1) Input shaft.

(2) Main shaft.

(3) Countershaft.

(4) Reverse idler gear.

(5) Reverse gear.

(6) First speed gear.

(7) Second speed gear.

118 b. **Trace the power flow from the input shaft to the output end of the mainshaft in each speed range.**

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ENLISTED MOS

CORRESPONDENCE/OJT COURSE

ORDNANCE SUBCOURSE 63B205

LESSON 4

MAINTENANCE OF CONVENTIONAL TRANSMISSIONS AND POWER TAKEOFFS

OCTOBER 1975

DEPARTMENT OF ARMY WIDE TRAINING SUPPORT
US ARMY ORDNANCE CENTER AND SCHOOL
ABERDEEN PROVING GROUND, MARYLAND

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US ARMY ORDNANCE CENTER AND SCHOOL
CORRESPONDENCE/OJT COURSE

LESSON ASSIGNMENT SHEET

Ordnance Subcourse No 63B205. . . . Wheeled Vehicle Clutches, Transmissions, and Transfers

Lesson 4. . . . . Maintenance of Conventional Transmissions and Power Takeoffs

Credit hours . . . . Three

Lesson Objectives . . . . After studying this lesson you will be able to:

1. Describe the procedures for inspecting a transmission.
2. Explain why lubricants may leak from a transmission.
3. List the procedures used to check for leaking oil seals.
4. List the procedures for checking malfunctions in a transmission.
5. Describe the procedures used to check for a worn or damaged synchronizer.

6. Describe the procedures for removal and replacement of an M151 1/4-ton truck transmission.

7. Describe the procedures for removal and replacement of an M35A1 or M35A2 2-1/2-ton truck transmission.

8. Describe the procedures for inspecting a power takeoff.

9. Explain the procedures used for testing for a broken gear tooth on the input or driving gear of a power takeoff (PTO).

10. Describe the procedure for inspecting a wrecker's rear power takeoff (PTO).

11. Explain the procedure for testing a malfunctioning PTO.

Text. . . . . Study Text

Materials Required . . . . Answer sheet and response list

Suggestions . . . . None

STUDY TEXT

FOREWORD

Although transmissions and power takeoffs are well made and sturdy, they can be a source of many maintenance problems. These components can be quickly ruined if the driver, either through ignorance, abuse, or neglect, fails to lubricate them or if he improperly shifts gears. Defects in other vehicle components can also cause damage to transmissions and power takeoffs. If, for example, the clutch is improperly adjusted and will not disengage, engine power cannot be disconnected from the transmission and gears may be damaged if the driver attempts to shift the transmission. Regardless of what problems occur, the mechanic must be prepared with the knowledge and skills needed to diagnose troubles and to make all repairs authorized at his maintenance level.

1. INTRODUCTION. This lesson is designed to acquaint you with the procedures to be followed when inspecting, testing, adjusting or repairing transmissions, and power takeoffs (PTO).

a. Remember, however, you should never be satisfied with just finding and correcting the trouble. You should always try to find what caused the trouble. If you find a transmission with broken gear teeth, don't be satisfied with just replacing the transmission. Try to find out what caused the gear teeth to break.

b. Whenever you find such components as the transmission and PTO in an unserviceable condition, talk to the driver. He may be able to explain exactly how the failure occurred and give you a clue as to the cause of the failure.

c. If you fail to find the cause, you will probably have to do the job over because the same trouble will likely develop in the replacement transmission or PTO.

2. INSPECTING THE TRANSMISSION. Leaking oil seals and gaskets are probably the most common causes of transmission and PTO problems. If such problems are not corrected in time, the gears, shafts, and bearings can be ruined.

a. There are many possible causes for oil seal or gasket failures, so always look for causes whenever you find such failures.

b. Foldout number 1 in the back of this pamphlet illustrates the transmission and transfer assembly used in the M151 1/4-ton truck. Notice the 18 numbered locations in the illustration where it is possible for the lubricant to leak out. In addition to the 18 locations shown, a crack in the transmission or transfer case housing can also allow the lubricant to escape.

3. CAUSE OF LEAKING LUBRICANTS. Now let's discuss some of the reasons why the lubricant is likely to leak at any one or several of these locations. First of all, a transmission (or almost any other gearcase) will usually start leaking if the oil level is too high. To stiffen the oil used in gearcases, soap and soda are usually added to the oil. As the gears operate the oil is splashed all over the inside of the gearcase. Because of the soap and partly because of the splashing and the heat, the oil starts to foam or fill with air bubbles. Thus the oil expands and takes up more room. This action creates excessive pressure inside the gearcase. If the oil level is too high to start with, the pressure created inside the transmission may be

more than the seals and gaskets can resist and the oil will start leaking out. Leaking can occur at any one or several of the locations shown in the illustration.

a. The transmission oil level should only be checked after the vehicle has been parked for several hours or overnight. During this time the bubbles or foam will cool and settle as a liquid in the bottom of the transmission case.

(1) With the transmission cold, remove the fill plug. The oil level should be at, or just below, the bottom of the fill plughole.

(2) If the oil level is too high, allow the excess oil to run out the fill plughole.

b. Even if the oil level is correct, it is possible that the foaming action of the oil will cause the pressure inside the transmission to become too high. To permit the excess pressure to escape, a vent valve (item 9) is used. This valve contains a seat and a spring-loaded ball and has a dust cap over the valve assembly. To check the vent valve, first make sure the area around it is free of dust and dirt. Then try turning the dust cap with your fingers. It should turn freely in either direction. If it does not turn freely, replace it.

c. Gaskets or oil seals will always leak if the bolts securing the plates, covers, or retainers are loose. All of the bolts should be tightened uniformly with a torque wrench.

(1) The bolts that secure the input shaft retainer (item 6), the gearshift housing cover (item 7), and those securing the retainer seals (items 2, 14, and 15) are all 5/16-inch bolts and should be tightened with a torque wrench to 10-14 lb-ft. Do not overtighten.

(2) The bolts that secure the transfer case to the transmission are 3/8 inch and should be tightened to 20-25 lb-ft. If tightening the bolts fails to stop a leak at this point, the using unit repairman should notify the motor officer or motor sergeant because replacing the transmission or transfer case gaskets is a job for a maintenance support unit.

(3) Leaks around the threads of the fill plug (item 4), the drain plugs (items 3 and 16), or any of the bolts can usually be stopped by coating the threads of the plugs or bolts with a lead-based paint.

(4) A loose gearshift retainer (item 8) will also allow the lubricant to escape.

(5) If there are leaks that cannot be stopped by tightening the bolts and plugs, or by coating the threads, notify your maintenance support unit.

(6) All of the seals need to be lubricated, otherwise they will be ruined. Therefore, a little seepage around any seal is normal. A seal is not considered as leaking unless enough oil is escaping by the seal to drip on the ground and cause a small puddle.

4. LEAKING SEALS. With the powerplant in the vehicle you can inspect all seals except the input shaft retainer seal (item 5). If this seal is leaking, oil will drip out through the plughole in the bottom of the pan under the flywheel housing when the plug is removed.

a. If oil does drip out at the flywheel housing drain plug, examine the oil closely. It may be engine oil leaking from the engine crankshaft rear oil seal. The engine oil is much thinner (has less viscosity) than the transmission oil, so you should be able to tell which seal is leaking.

b. An oil leak, either from the engine or transmission input shaft seals, is serious because the oil can ruin the clutch. An oil soaked clutch disk will almost always slip or grab.

5. TESTING TRANSMISSIONS FOR MALFUNCTIONS. In addition to the leakage problems, there are other problems that can develop in the transmission used in the 1/4-ton truck. We can classify these as mechanical problems.

a. The best way to locate mechanical problems in the transmission is to road test the vehicle. Before road testing, however, check for missing or loose bolts and be sure the oil is at the proper level in the transmission case. Check the parking brake mechanism for proper mounting and correct adjustment. Check all moisture seals or boots. Check the action of the gearshift levers.

b. The transmission is often blamed for problems that are elsewhere. For example, with the engine running and the vehicle standing still, disengage the clutch and move the gearshift lever into first or reverse. You should be able to shift into either of these gear positions without any gear clashing or without the vehicle moving. If the gears clash or the vehicle attempts to move with the clutch disengaged, the trouble is in the clutch and not the transmission.

(1) Check the clutch pedal free travel and adjust if necessary. The clutch must be correctly adjusted before the transmission can operate properly. The clutch must fully disengage everytime the clutch pedal is pushed all the way down, and fully engage everytime the pedal is released.

(2) With the transmission in neutral, the engine running, and the clutch engaged, all of the constant mesh gears in the transmission will be turning. There should be very little gear or bearing noise.

(3) If the transmission is quiet in neutral with the clutch engaged, disengage the clutch. If a noise is now heard, the trouble is the clutch and not the transmission. Usually, the clutch release bearing or the clutch shaft pilot bearing is at fault if a noise is heard only when the clutch is disengaged.

(4) Sometimes noises in other parts of the power train, such as U-joints, propeller shafts, and differentials, sound as if they are in the transmission. Misalinement of power train components usually produces a noise that may sound as if it is coming from the transmission. So be sure to check all mounting bolts on the engine, transmission, and differentials before road testing the vehicle. Also check the propeller shafts and U-joints for evidence of wear or looseness.

(5) Loose, bent, or shifted suspension system components will cause misalinement of the power train components which can produce a noise that may sound like a defective transmission.

(6) Noises that may originate in the transmission are difficult to describe. A noise that may sound like a howl to you may sound like a squeal to someone else. Other terms often used to describe gear or bearing noises may include such words as "hum," "knock," "grind," "whine," and "thump."

(7) If a tooth is broken off of one of the gears, a distinct thumping noise will be heard once during a complete revolution of the gear. The thump will be more pronounced if torque is being delivered through that gear.

(8) Gears with worn, rough teeth will usually produce a grinding noise, especially when torque is being transmitted through them.

(9) Bearing noise is usually described as a howl, whine, or squeal. Actually, the type of noise made by a defective bearing will vary, depending on the type of defect and the load the bearing is supporting. In any event, loud noises coming from inside of the transmission mean trouble.

c. Some whine or grinding noise can be expected, especially when the vehicle is being driven in first or reverse gear. The first and reverse sliding gear together with its mating countershaft gear and reverse idler gear are spur gears. Spur gears are always noisy, but, as you recall from a preceding lesson, they are frequently used because they are cheaper and do not produce thrust.

(1) In the second, third, and fourth speed ranges the transmission should be much quieter than in first or reverse.

(2) If, after a road test, you think the transmission is too noisy, be sure and report it to the motor sergeant. Be sure to describe the conditions under which the noise occurs.

d. Another common mechanical problem with transmissions of this type is slipping or jumping out of gear. Foldout number 2 in the back of this pamphlet illustrates the six most likely reasons for a transmission to slip out of first or reverse gear. The numbers in the illustration show the order in which this trouble is likely to occur (1 is the most likely—6 is the least likely to cause the trouble).

(1) Actually, the transmission is much less likely to slip or jump out of first or reverse than out of the second, third, or fourth speed gear. Second, third, and fourth speed gears are all helical gears, which, you recall, produce thrust.

(2) Notice in A, B, and C that the most likely causes of the transmission slipping out of gear are worn detent balls or springs in the shifter shaft cover. These spring-loaded balls hold the shifter shaft in position and if the spring doesn't have enough tension, or if the balls are worn, the transmission will almost certainly slip or jump out of gear.

(3) Slipping out of any gear is most likely to occur when the driver suddenly takes his foot off of the accelerator pedal— especially when descending a steep hill. The thrust produced by the helical gears will tend to move all rotating gears and shafts to the rear of the transmission, as long as the torque provided by the engine is being delivered to the rear wheels by the transmission. However, when the driver takes his foot off of the accelerator pedal, the situation is changed. The rear wheels now try to drive the engine through the transmission. This reverses the direction of the torque being delivered through the transmission gears, and the thrust is now toward the front of the transmission. If this thrust is not controlled by the thrust washers and bearing retainers, it is likely to force the shifter shaft to move in spite of the spring-loaded ball that holds it. When this happens, the transmission slips out of gear.

(4) Occasionally a transmission slips out of gear because the driver does not fully engage the gear when he moves the lever. However, a transmission that slips out of gear fairly often should be replaced.

6. SYNCHRONIZER DAMAGED. Notice in B that a worn or damaged synchronizer is the second most likely cause of the transmission slipping out of gear (in this case second speed gear). The third and fourth speed synchronizer can also be at fault if the transmission slips out of third or fourth speed gear.

a. Usually, however, there is another clue if one of the synchronizers is worn or broken.

b. Remember, the synchronizers use bronze or brass alloy cone clutches to bring two gears to the same speed before the gears actually engage (mesh). If these cone clutches are worn to the extent they fail to bring the gears to the same speed before they mesh, a distinct grinding noise will be heard as the gears clash together. Gears always clash if they are in contact with each other while traveling at different tooth speeds.

(1) Let's suppose that the transmission can be shifted into first or reverse without gear clash while the engine is running but the vehicle is not moving. If we get no gear clash when shifting from neutral to first or reverse, we know the clutch fully disengages when the clutch pedal is pushed down all of the way.

(2) Let's start the vehicle moving forward in first gear. At 10 miles per hour (MPH) we depress the clutch pedal and shift into second gear. Now we get a distinct gear clash. The clash is not caused by the failure of the clutch to disengage. We proved it would disengage when we shifted into first. The clashing noise, therefore, indicates a defective second speed synchronizer (probably the cone clutch in the synchronizer).

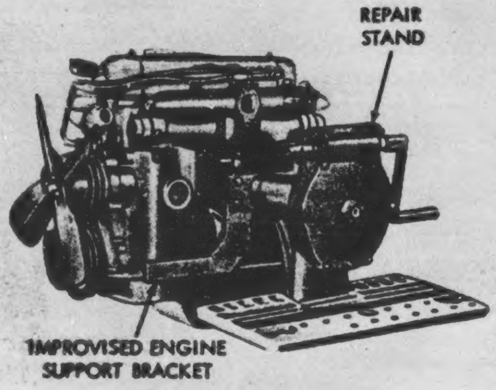
(3) Now shift into third speed. If we get no noise during this shift, we can definitely assume that the second speed synchronizer is defective. To correct this condition it is necessary to replace the transmission.

SECTION II. TRANSMISSION REPLACEMENT

7. **REMOVE AND REPLACE M151 TRUCK TRANSMISSION.** The organizational mechanic is authorized to replace the transmission if permission is given by the maintenance support unit.

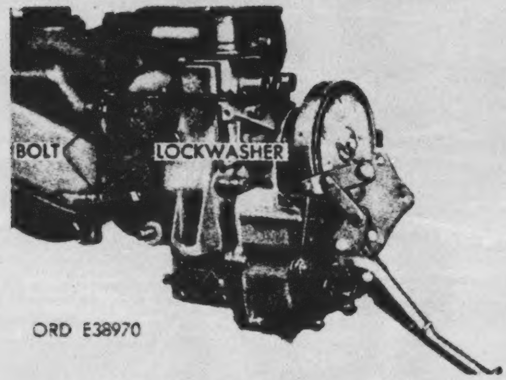
a. To replace the transmission in the M151 truck, it is necessary to remove the entire powerplant from the vehicle. Remember, in subcourse 63B202, you learned that the powerplant consisted of the engine, clutch, transmission and transfer assembly, and the radiator.

b. Follow the procedures described in subcourse 63B202 and remove the powerplant from the vehicle. Place the powerplant on repair stand.

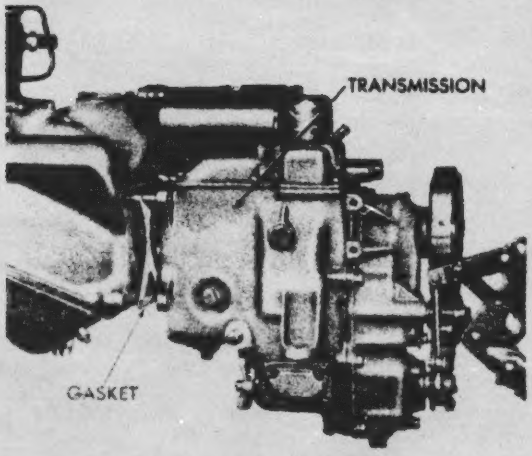


(1) Place an oil drain pan under the transmission and transfer assembly. Remove the oil drain plugs from both the transmission and transfer case. Allow the oil to drain out, then replace the drain plugs.

(2) Remove the four bolts that secure the transmission to the flywheel housing.



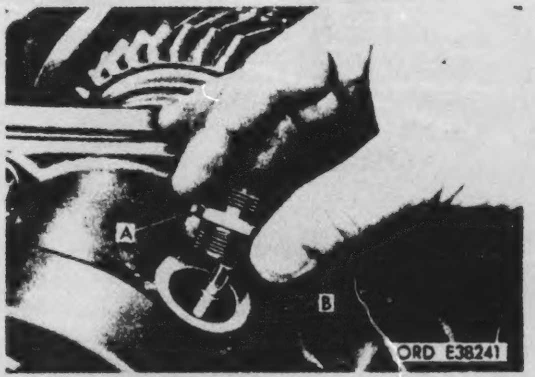
(3) Use a rope sling or floor jack to support the weight of the transmission, then slide the transmission to the rear until it clears the flywheel housing.



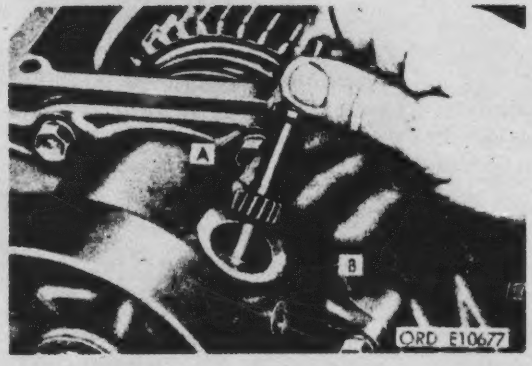
(4) Disconnect the parking brake lever rod from the control linkage and remove the parking brake lever.

(5) If the replacement transmission and transfer assembly is received without the speedometer driven gear and bearing, remove these items from the top of the transfer case you removed from the vehicle. Install the driven gear and bearing on the replacement transfer case.

A



B



(6) Clean the input shaft retainer and lightly coat the sleeve portion of the retainer with oil. Do not oil the clutch splines on the input shaft, but put a light coat of grease on the pilot bearing portion of the shaft.

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(7) Check inside the engine flywheel housing to see if the clutch release bearing is correctly mounted on the clutch lever fork.

(8) Mount the new transmission to flywheel housing gasket on the flywheel housing, using a light coat of grease to hold it in place.

(9) Position the replacement transmission in line with the center of the engine flywheel housing. Slide the transmission forward, making sure that the transmission input shaft and retainer sleeve go through the clutch release bearing. Rock the transmission back and forth slightly until the input shaft splines engage the splines on the clutch disk. Push the transmission forward until it is flush with the flywheel housing.

(10) Install the four transmission to flywheel housing bolts and tighten them with a torque wrench to 37-42 lb-ft.

(11) Fill the transmission with the appropriate lubricant through the fill plughole.

(12) Replace the powerplant in the vehicle. Be sure to install the parking brake lever.

(13) Check the clutch pedal free play and adjust if necessary.

(14) Road test the vehicle. Note especially the action of the transmission in all speed ranges. Check to make sure that the front wheel drive will engage and disengage.

(15) Finally allow the vehicle to sit for at least 2 or 3 hours and recheck the oil level in the transmission. Add oil up to the proper level if necessary.

8. REMOVAL AND REPLACEMENT OF TRANSMISSIONS ON 2-1/2-TON TRUCKS. The transmission used on the 2-1/2-ton truck, M35A1 or M35A2, is somewhat larger than the one used on the M151 truck. The 2-1/2-ton truck transmission has five forward speeds and one reverse.

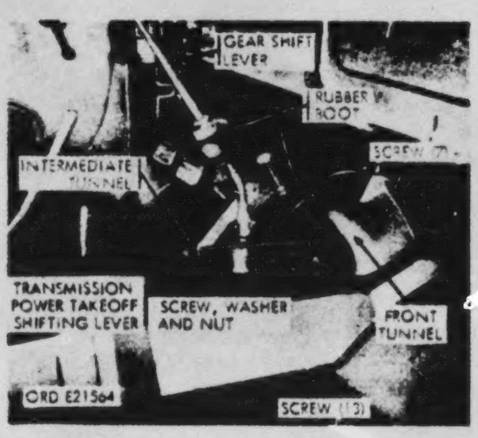
a. In general the procedures for inspecting and testing the larger transmissions are the same as those on the M151 truck. However, the transfer case on the 2-1/2-ton truck is independent of the transmission. A propeller shaft is used to connect the transmission and transfer.

b. Organisational maintenance personnel are authorized to replace the transmission in the 2-1/2-ton truck if they first obtain permission from their support maintenance unit.

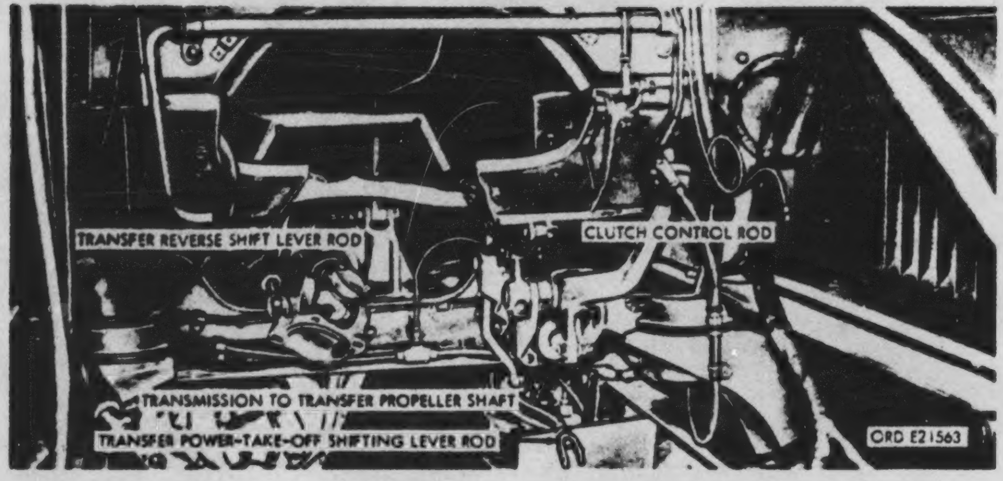
c. The transmission can be removed from the vehicle without removing the engine. The procedures for removing and replacing this transmission are as follows:

(1) Park the vehicle on a level floor and block the rear wheels.

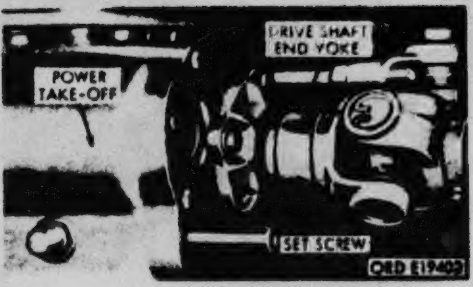
(2) Begin the removal operation in the cab of the vehicle. Raise the gearshift lever boot and remove the screw, washer, and nut holding the lever to the transmission. Remove the lever. Remove the screws holding the front and intermediate tunnels and remove them from the floor of the cab. It is not necessary to remove the rear tunnel.



(3) Disconnect the clutch control rod from the clutch throwout shaft lever at the clutch housing. Disconnect the transfer reverse shift lever rod from the reverse shift lever at the transmission. You are now ready to disconnect the transmission to transfer propeller shaft at the transmission. However, before disconnecting the propeller shaft you must always raise one front wheel off the ground to relieve strain from the shaft. Failure to observe this warning may result in painful injuries. This precaution is necessary because the drive to the front wheels is automatically engaged and disengaged and can cause a windup in the entire gear train. This drive will be covered in a later lesson.

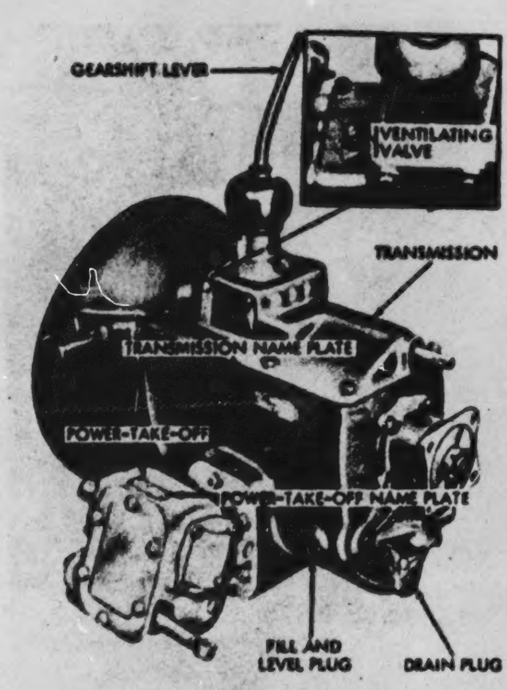

TRANSFER REVERSE SHIFT LEVER ROD
CLUTCH CONTROL ROD
TRANSMISSION TO TRANSFER PROPELLER SHAFT
TRANSFER POWER-TAKE-OFF SHIFTING LEVER ROD
ORD E21563

(4) On vehicles equipped with a front winch, disconnect the front winch drive shaft. Loosen the socket-head setscrew in the stop collar at the power takeoff and push the yoke off the power takeoff output shaft. Also disconnect the transmission power takeoff shifting lever rod at the power takeoff.



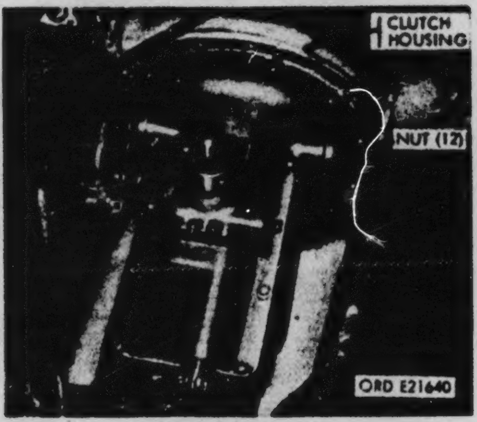
ORD E19403

(5) Drain the transmission by removing the drain and fill plugs. Allow the oil to drain completely. Install the plugs to prevent drip and to insure against the loss of plugs.



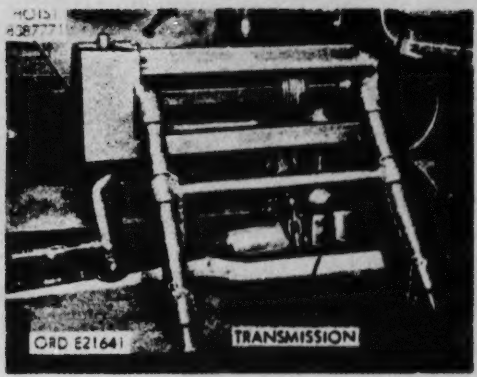
ORD E21639

(6) Loosen the screw holding the flywheel ground strap to the flywheel housing and slide the strap out from under the screw. Loosen the top two nuts which hold the transmission to the clutch housing. Leave these nuts loose but do not remove them at this time. Remove the other ten nuts and lockwashers.

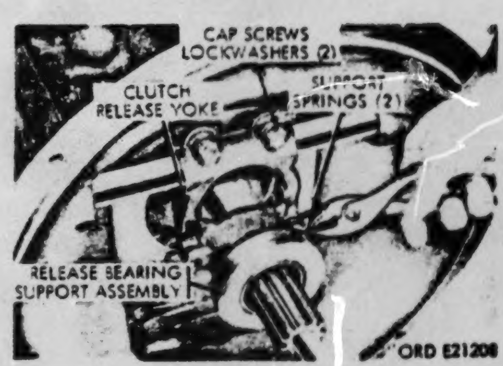


ORD E21640

(7) Place a chain around the transmission and install and attach a hoist to the chain. Operate the hoist to take up the weight of the transmission. Now remove the two nuts and lockwashers which you loosened at the top of the transmission. Slide the transmission back until the input shaft clears the clutch plate and housing. Lower the transmission on to a low-wheel dolly and remove it from under the vehicle. Remove the power takeoff and transmission ventilating valve if the replacement transmission is short these items. Install them on the replacement transmission.



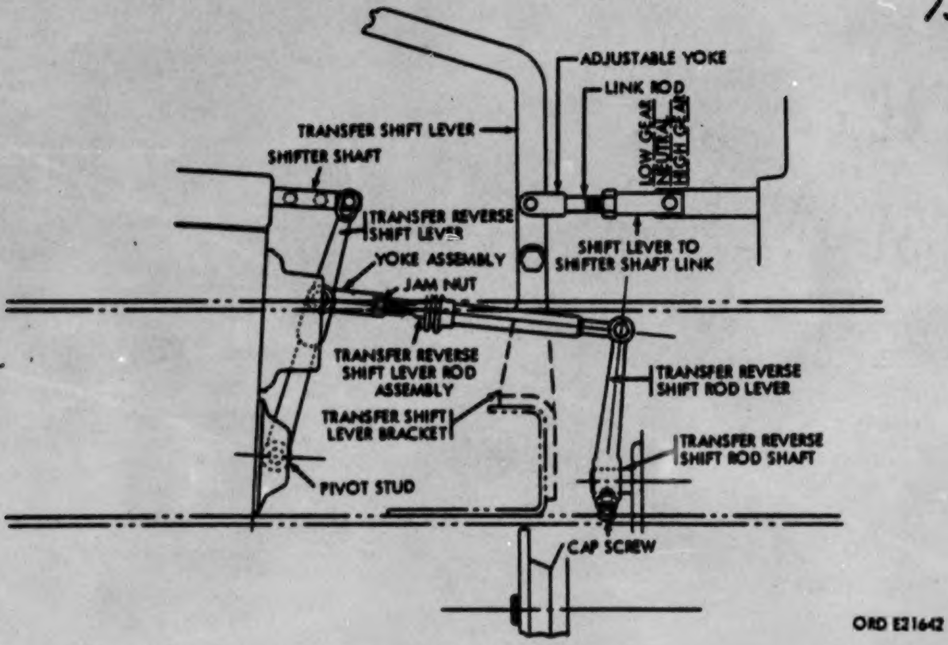
(8) Remove the clutch release bearing support from the old transmission. Clean and lightly lubricate the inside of the bearing support and install it on the replacement transmission. Do not wash the release bearing in solvent or any other liquid. The release bearing is packed with grease and sealed at the factory. It may be ruined if washed because it cannot be relubricated.



(9) Installing the transmission in the vehicle is merely reversing the removal procedures.

(10) Be sure to fill the transmission to the correct level with the proper lubricant.

(11) Adjust the clutch and transfer reverse shift linkage if necessary. The clutch pedal free travel should be from 1-1/2 to 2 inches. The procedures for adjusting the transfer reverse shift linkage are explained in a later lesson of this subcourse. They are also explained in TM 9-2320-209-20.


ADJUSTABLE YOKE
LINK ROD
LOW GEAR
NEUTRAL
HIGH GEAR
TRANSFER SHIFT LEVER
SHIFTER SHAFT
TRANSFER REVERSE SHIFT LEVER
YOKE ASSEMBLY
JAM NUT
SHIFT LEVER TO SHIFTER SHAFT LINK
TRANSFER REVERSE SHIFT LEVER ROD ASSEMBLY
TRANSFER SHIFT LEVER BRACKET
TRANSFER REVERSE SHIFT ROD LEVER
TRANSFER REVERSE SHIFT ROD SHAFT
PIVOT STUD
CAP SCREW
ORD E21642

(12) Road test the vehicle and note especially the action of the clutch and transmission.

(13) After the road test, recheck all connecting points and the transmission oil level. Be sure to allow enough time for the oil to settle before checking the level.

SECTION III. POWER TAKEOFF MAINTENANCE

9. INSPECTION AND TESTING. Specific procedures must be followed when inspecting, testing, and servicing the PTO and related parts.

a. On military vehicles, PTO's are most commonly used to drive winches. The winches are usually mounted on the front of the vehicles, although some vehicles, such as wreckers, also have winches mounted at the rear. In the case of the wreckers, separate PTO's are used to drive each winch.

b. The procedures for inspecting and testing PTO's are similar to those followed when inspecting and testing the transmission.

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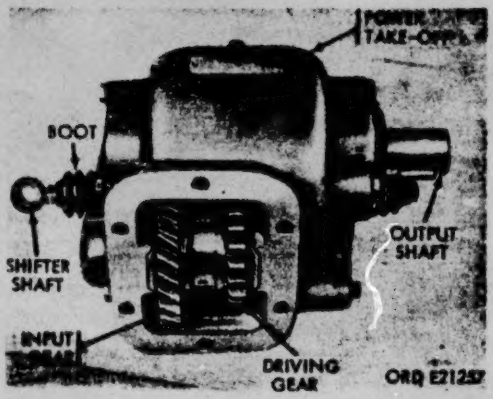
c. The input gear of the PTO used to drive the front winch on a 2-1/2-ton truck is in constant mesh with the reverse idler gear on the transmission countershaft. The PTO input gear and driving gear are turning anytime the engine is running and the clutch is engaged. They are also turning if the vehicle is moving. Therefore, worn or broken PTO input or driving gear teeth, or defective bearings, can cause noises that sound as if they are coming from the transmission.



d. Leaking PTO gaskets or seals will also cause a loss of transmission oil, because the PTO is bolted to the transmission and is lubricated by the oil from it.

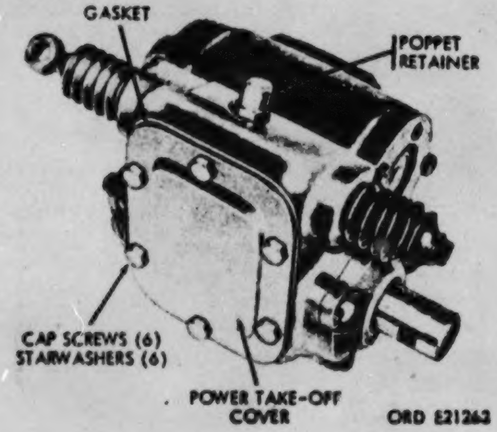
e. The most likely places for oil leaks from the PTO are:

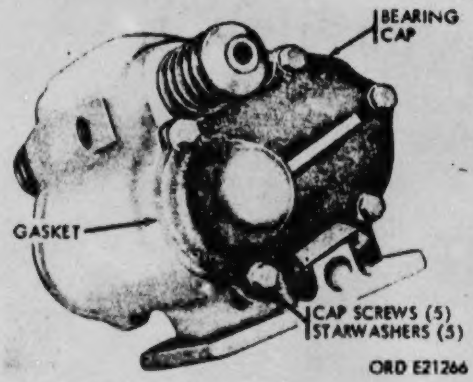
(1) The mounting flange gasket between the PTO and the transmission.

(2) The PTO cover, capscrews, and cover gasket.

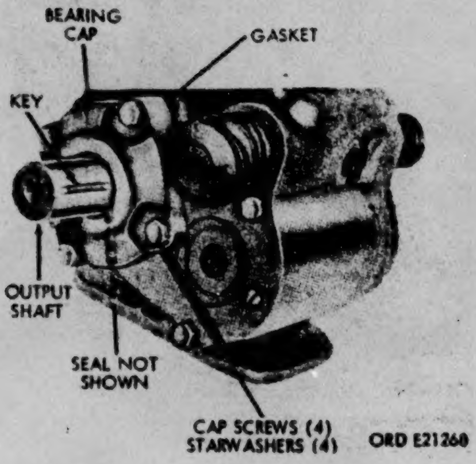
(3) The poppet ball retainer.

(4) The output and reverse shaft rear bearing cap.

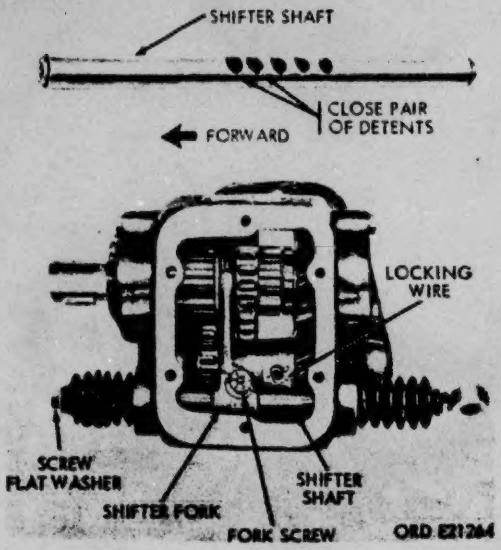




(5) The output shaft bearing cap, gasket, and seal.



(6) The bellows-type boots or seals at both ends of the shifter shaft.



f. Any of the leaks around the mounting flange, bearing caps, or cover gaskets may be corrected by tightening the mounting screws or nuts to the proper torque. If tightening the screws and nuts fails to stop the leaks, notify your support maintenance unit. Replacing the seals is also a job for the support maintenance unit.

10. BROKEN GEAR TOOTH TEST. A broken gear tooth on the input or driving gear will produce a thumping noise once during each revolution of the gear. The noise produced may sound as if it is coming from the transmission instead of the PTO.

a. To determine whether or not the gear with the broken tooth is in the transmission or the PTO proceed as follows:

(1) Drain the oil out of the transmission.

(2) Remove the PTO cover and cover gasket.

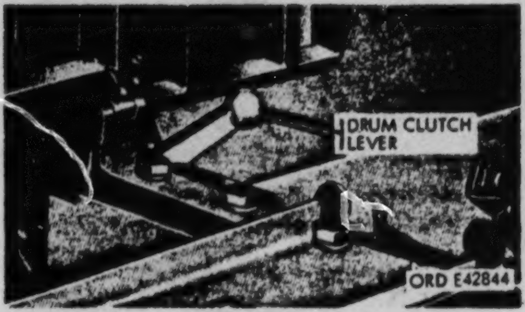
(3) With the cover removed, you can see about one-half of the teeth on the PTO gears.

(4) Have an assistant in the cab place the transmission in neutral and apply the parking brake.

(5) With the ignition switch off and the clutch engaged, have the assistant bump the starter switch.

(6) Inspect all of the PTO gear teeth while the assistant bumps the starter switch. With the clutch engaged the starter will turn all of the constant mesh gears in the transmission and the input gear in PTO. However, the PTO sliding gear will not be turning.

(7) To check the sliding gear, shift the front winch drum clutch lever to the disengaged position by pushing the lever toward the winch drum.



(8) Shift the PTO shift lever into any of the engaged positions.

(9) Inspect the sliding gear while your assistant bumps the starter.

b. If no teeth are broken on the gears in the PTO, it is safe to assume the noise is coming from the transmission.

c. However, if a gear with a broken tooth is found in the PTO try to find the cause. Broken gear teeth are usually the result of improper shifting or putting too much strain on the teeth.

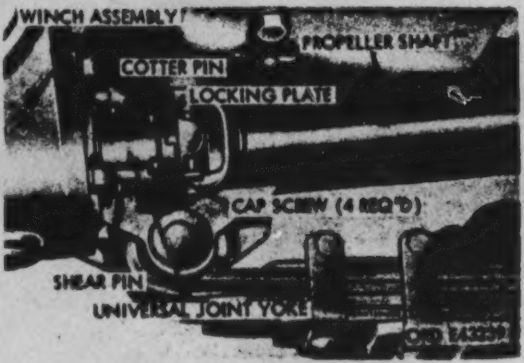
(1) Too much strain on the teeth can be the result of impact loads or overloads.

(2) An impact load (also called a shock load) can be compared to a hammerlike blow on a nail or a screw instead of a steady push.

(3) Gears are subjected to impact loads whenever the driver races the engine and, at the same time, jerks his foot off of the clutch while the transmission or PTO is in gear. Such action causes the driving gear teeth to strike the driven gear teeth like a hammer. If the clutch is released slowly, the driving gear will push against the driven gear teeth and the load is applied gradually.

d. To protect the transmission, PTO, and winch against overloads, a shearpin is provided.

(1) The shearpin is illustrated in this figure. It is usually made of aluminum or some other soft metal and is designed to be the weak link in the PTO to the winch drive. The propeller shaft delivers the torque from the PTO to the winch. The U-joint (yoke) on the propeller shaft is locked to the winch worm gear shaft by the soft metal shearpin. Because this pin is the weak link in the drive, it is supposed to break before too much overload or strain is placed on the gears.

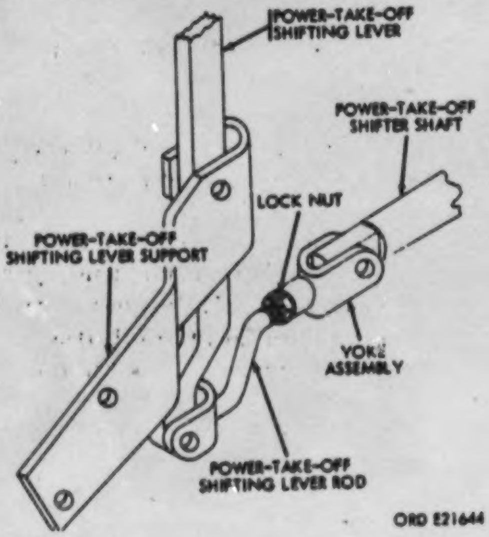


(2) Sometimes, however, if the shearpin breaks and the driver cannot find another one, he uses a steel punch or bolt instead. Now instead of being the weakest link, the steel punch is the strongest link. It no longer protects the gears and the winch.

(3) Always check the shearpin to make sure that the right one is being used.

e. Gear teeth may also be broken because they do not fully engage when a shift is made from neutral to one of the gear driving positions. Improper adjustment of the PTO shift linkage is the most likely cause of this condition.

(1) To check the PTO shift linkage on the 2-1/2-ton truck for proper adjustment, remove the pin that connects the yoke assembly to the PTO shifter shaft. Grasp the shaft and attempt to move it by pushing or pulling. It should be difficult, if not impossible, to move the shaft. If, however, the shaft moves slightly and then locks, the detent ball is not seated in one of the detent holes on the shifter shaft.


POWER-TAKE-OFF SHIFTING LEVER
POWER-TAKE-OFF SHIFTER SHAFT
LOCK NUT
POWER-TAKE-OFF SHIFTING LEVER SUPPORT
YOKE ASSEMBLY
POWER-TAKE-OFF SHIFTING LEVER ROD
ORD E21644

(2) Have your assistant in the cab of the truck hold the shift lever so it does not move.

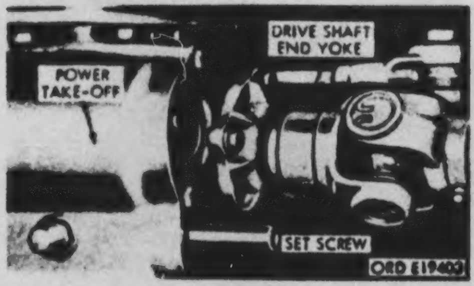
(3) Loosen the yoke locknut and turn the yoke in or out of its threads until the yoke pin will slide through the yoke and shifter shaft.

(4) Now have your assistant move the lever to each shift position in turn. At each position remove the yoke pin and make sure the ball drops into the detent hole on the shaft.

(5) After checking in all shift positions, install the yoke pin cotter key and tighten the yoke locknut.

f. Failure of the PTO to shift properly may also be due to a loose or missing shifter fork lock screw or to a badly worn fork. If the linkage is properly adjusted, remove the PTO cover and check the fork and lock screw.

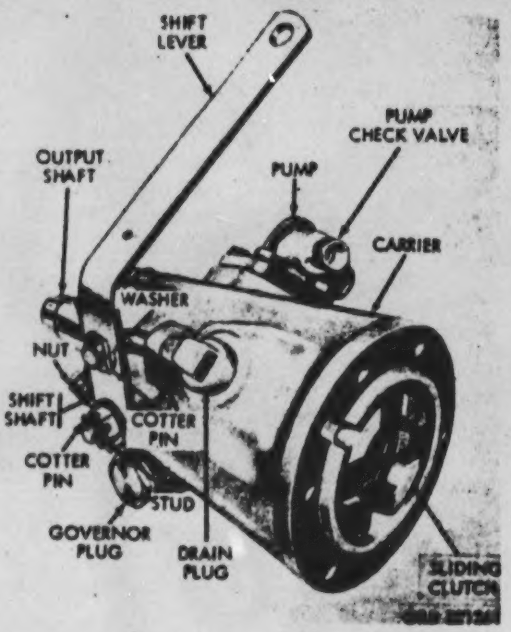
g. The drive shaft end yoke is coupled to the PTO output shaft. Notice the setscrew that keeps the yoke from sliding endwise (back and forth) on the output shaft. This setscrew must be kept tight, otherwise the key used to lock the yoke to the output shaft will wear rapidly and probably break.



11. WRECKER PTO'S. In addition to the PTO described above, some military vehicles, such as the M60, M108, M62, and M543 wreckers, have a PTO that is mounted on the rear of the transfer case.

a. This PTO is a single speed unit and on all wreckers, except the M108, it drives a power divider.

b. Notice that there are some additional units on this PTO. The oil pump operates anytime the PTO is engaged. It draws the oil from the bottom of the transfer case to lubricate the PTO and the transfer input gearing.



c. This unit also has a governor that overrides the regular engine speed governor and limits the engine to about 1,700 RPM.

d. Inspect this PTO for leaks, especially around the output shaft seal and around the mounting flange gasket and bolts. Tighten the mounting flange bolts if necessary.

e. The shift lever has only 2 positions — engaged (in gear) or disengaged (out of gear).

f. When engaged, the sliding jaw clutch moves forward to mesh with a mating jaw clutch in the transfer case.

g. To engage the PTO proceed as follows:

(1) Lock the brakes.

(2) Start the engine and disengage the clutch.

(3) Shift the transfer into neutral.

(4) Shift the PTO lever into the engaged position.

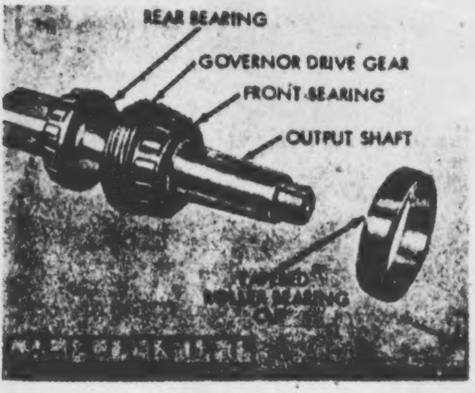
(5) Shift the transmission into 5th gear on the M60, M62, and M108, or into 4th gear on the M60A2, M543, and M543A2. (5th gear is direct drive (1:1 ratio) on the 1st three wreckers listed, but 4th gear is direct drive on the last three listed.)

(6) Accelerate the engine to the maximum governed speed. If the governor on the PTO is operating, it should not allow the engine to exceed about 1,700 RPM. If the engine speed exceeds 1,800 RPM, release the accelerator.

(7) With the engine running at 1,700 RPM or less, check the PTO output shaft to see if it is turning.

12. MALFUNCTIONING PTO. If the engine speed exceeds 1,800 RPM, or if the PTO output shaft is not turning when it is in the engaged position, stop the engine.

a. Have an assistant in the cab operate the gearshift lever while you observe the PTO. If the shift lever operates properly, but the engine overspeeds when the PTO is engaged, notify your support maintenance unit.



b. Finally it is possible that the PTO output shaft is turning, but the propeller shaft is not. Notice that the output shaft is tapered and that the end of the shaft is threaded. Notice, too, that the output shaft is slotted for a key. The key locks the output shaft to the propeller shaft companion flange to drive the propeller shaft. The companion flange is held tightly on the key by the nut that is screwed onto the threaded part of the output shaft.

c. If this nut is loose or missing, the companion flange may slide endwise on the shaft and off of the key. Then the PTO output shaft can turn without turning the propeller shaft companion flange. Be sure this nut is tight at all times.

SECTION IV. CONCLUSION

13. SUMMARY. We have only covered a few of the wheeled vehicles on which you will have to maintain the transmission and power takeoff. The procedures for maintaining the transmissions of other vehicles are much the same.

14. PRACTICE TASKS. Appendix B of this lesson contains a list of tasks associated with the maintenance of conventional transmissions and power takeoffs. They are representative of the tasks you will be required to perform as a wheeled vehicle mechanic. Perform all of the tasks listed. Be sure you are under the supervision of an officer, NCO, or specialist qualified in the MOS when you practice the tasks. If you find you are having difficulty in certain tasks, restudy the appropriate training material and practice the tasks until you become proficient in each one.

EXERCISE

Note. - Review the lesson exercise directions in lesson 1 before answering the following questions.

56. The most frequent cause of trouble in the M151 truck transmission is

    a. loose mounting bolts.
    b. lubricant leakage.
    c. worn bearings.

57. The speedometer driven gear bearing on the M151 truck is threaded into the

    a. left side of the transmission.
    b. top of the transfer case.
    c. bottom of the transfer case.

58. The M151 truck transmission is secured to the clutch housing by

    a: four studs and nuts.
    b. four bolts.
    c. six bolts.

59. Before disconnecting the transmission to transfer case propeller shaft on the 2-1/2-ton truck, it is necessary to

    a. jack up one front wheel.
    b. disconnect the transfer shift lever.
    c. disconnect the parking brake rod.

60. How many synchronizers are used in the 1/4-ton truck transmission?

    a. 3
    b. 2
    c. 1

61. The input gear for the transmission mounted PTO is on the same shaft as the

    a. reverse idler gear.
    b. low-speed gear.
    c. driving gear.

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62. What is used in the transmission to prevent the buildup of pressure due to the foaming of the oil?

a. Bypass valve
b. Leak-off tube
c. Vent valve

63. What is likely to be ruined by a leaking oil seal in the transmission input shaft bearing retainer?

a. Clutch
b. Power takeoff
c. Pilot bearing

64. The most likely cause of a transmission slipping out of gear is worn

a. detent balls and springs.
b. synchronizer cones.
c. thrust washers.

65. The propeller shaft to the front winch of the 2-1/2-ton truck is secured to the winch worm gear shaft by a

a. nut and cotter pin.
b. shear pin.
c. snapring.

66. When using the rear winch on the M543 or M543A2 wrecker, the transfer should be in neutral and the transmission in

a. third gear.
b. fourth gear.
c. fifth gear.

67. The PTO to the rear winch includes an oil pump and a

a. power divider.
b. shear pin.
c. governor.

68. The transmission to transfer case bolts on the 1/4-ton truck should be torqued to

a. 15-19 lb-ft.
b. 20-25 lb-ft.
c. 26-30 lb-ft.

69. With the powerplant installed in the 1/4-ton truck all of the transmission oil seals can be inspected except the

    a. input shaft.
    b. counter shaft.
    c. output shaft.

70. Why should a vehicle be parked several hours before checking the oil level in the transmission?

    a. Permit the oil to cool and shrink
    b. Permit the foam to cool and settle
    c. Permit the pressure to escape

71. If the transmission is quiet in neutral with the clutch engaged but a noise is heard when the clutch is disengaged, the trouble is probably caused by the

    a. synchronizer clutch.
    b. drive gear.
    c. release bearing.

72. The transmission is most likely to jump out of gear when

    a. a load is applied to the engine while operating in fourth gear.
    b. deaccelerating going down hill in fourth gear.
    c. operating in first gear.

73. The transmission should be much quieter when it is operated in

    a. reverse.
    b. first.
    c. third.

74. What should be used to tighten the gearshift housing cover of a transmission?

    a. Box-end wrench
    b. Adjustable wrench
    c. Torque wrench

75. How is the drive shaft end yoke coupled to the PTO output shaft?

    a. Set screw
    b. Shear pin
    c. Snapring

APPENDIX A

REFERENCES

TM 9-2320-209-20, w/C1-6	Organizational Maintenance Manual for the 2-1/2-Ton, 6x6, M34, M35, and M36 Series Trucks	Apr 65
TM 9-2320-211-20	Organizational Maintenance Manual for the 5-Ton, 6x6, Tractor Trucks, Cargo Trucks, and Wreckers	Jun 73
TM 9-2320-218-20, w/C2	Organizational Maintenance Manual for 1/4-Ton, 4x4, M151 Series Trucks	Sep 71

APPENDIX B

PRACTICE TASK LIST

Practice Objective . . . . **After practicing the following tasks you will be able to:**

1. **Inspect the transmission of a wheeled vehicle.**
2. **Check a vehicle transmission that is leaking lubricant.**
3. **Check a vehicle transmission using the procedures for a leaking oil seal.**
4. **Test a vehicle transmission to locate mechanical malfunctions.**
5. **Inspect a power takeoff (PTO).**
6. **Test for a broken gear tooth on the input or driving gear of a PTO.**
7. **Inspect the rear PTO of a wrecker.**
8. **Test for a malfunctioning PTO.**

1. The organizational mechanic will be required to inspect, test, and do some repair on transmissions and PTO's. Here are a few of the things you should practice on each type of vehicle in your unit.

a. Inspect the transmission for:

(1) Leaking seals and gaskets.

(2) Loose or missing bolts.

(3) Reverse shift linkage adjustment (if used).

(4) Gear clash.

(5) Noisy gears or bearings.

(6) Jumping out of gear.

(7) Oil level.

(8) Vent valve.

b. Repair and adjust the transmission to include:

(1) Adjusting linkage (if used).

(2) Tightening or replacing mounting bolts.

(3) Replacing vent valve.

c. Inspect the PTO checking specifically for:

(1) Leaking seals or gaskets.

(2) Loose or missing bolts.

(3) Sheared shearpin.

(4) Loose drive shaft yoke mounting.

(5) Gear or bearing noise.

(6) Proper operation of the PTO.

2. Assist experienced repairmen in the removal and installation of a transmission and/or PTO on a 1/4-, 3/4-, 1-1/4-, 2-1/2-, and 5-ton truck. Because this is normally done by support maintenance personnel, you arrange to visit your support maintenance unit shops or work with a support maintenance contact team in your area. During the removal and installation procedures pay special attention to the following for each type of vehicle:

a. The work that must be done inside the cab and under the vehicle.

b. Whether or not the engine must be removed.

c. The lifting and holding procedures used.

d. The work that must be done on a replacement transmission or PTO before it is installed.

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e. The procedures for alining the transmission input shaft with the clutch disk spline and engine flywheel pilot bearing.

f. The tightening of mounting bolts to the prescribed torque rating.

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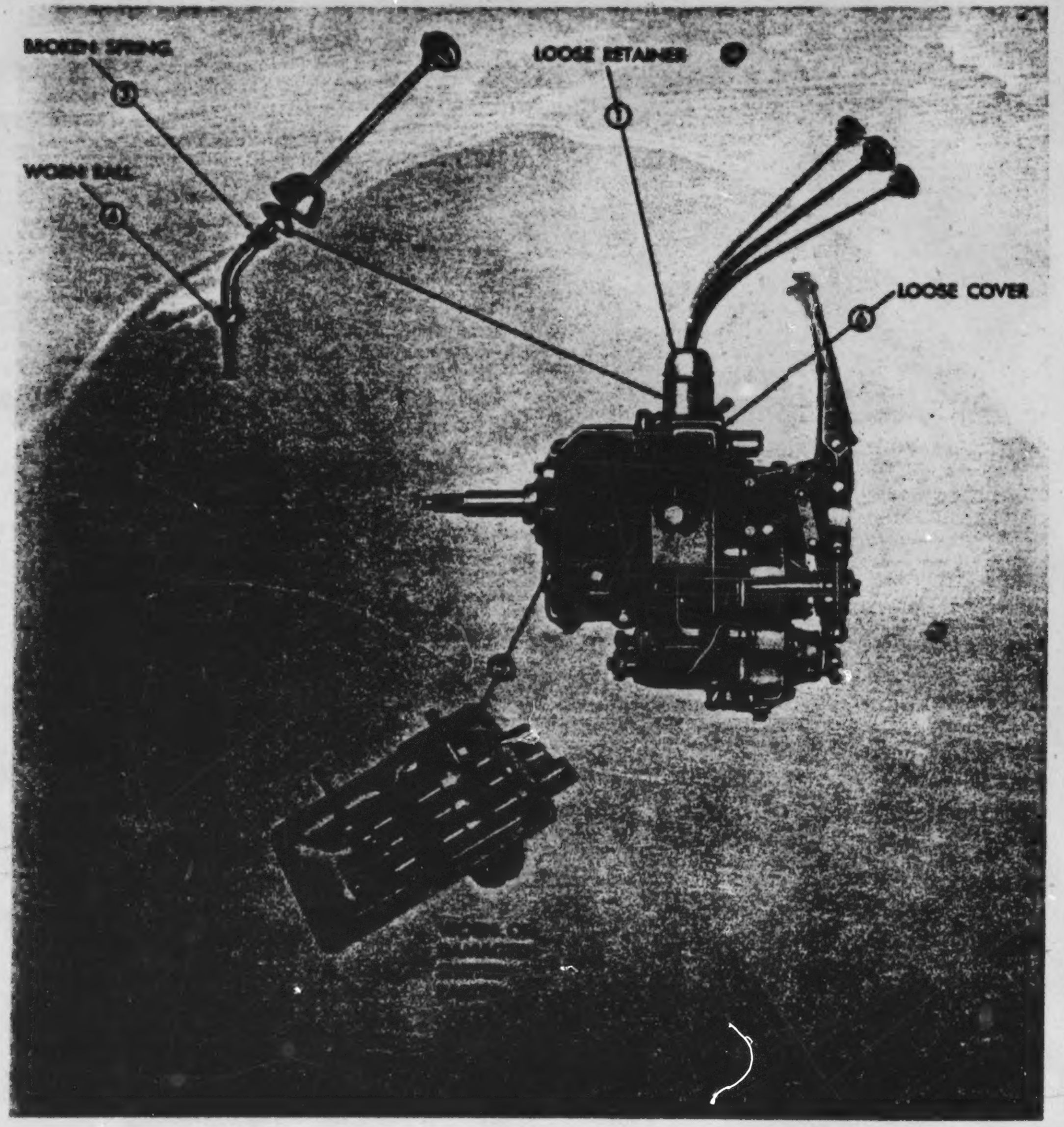
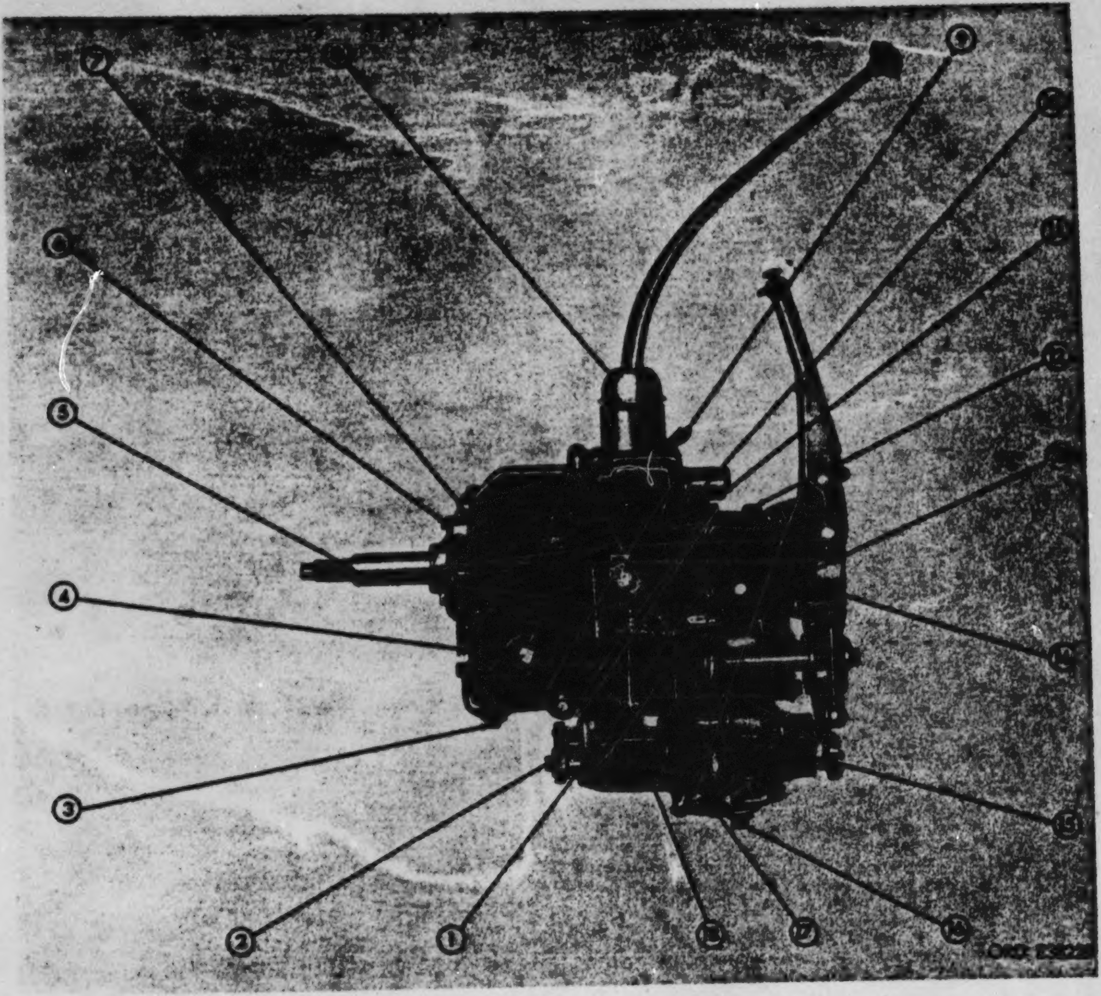
148 **Note.** Key numbers show order in which troubles will most likely occur.



CORRECTIVE ACTION: Tighten loose parts, replace damaged or worn parts.

Foldout number 1.

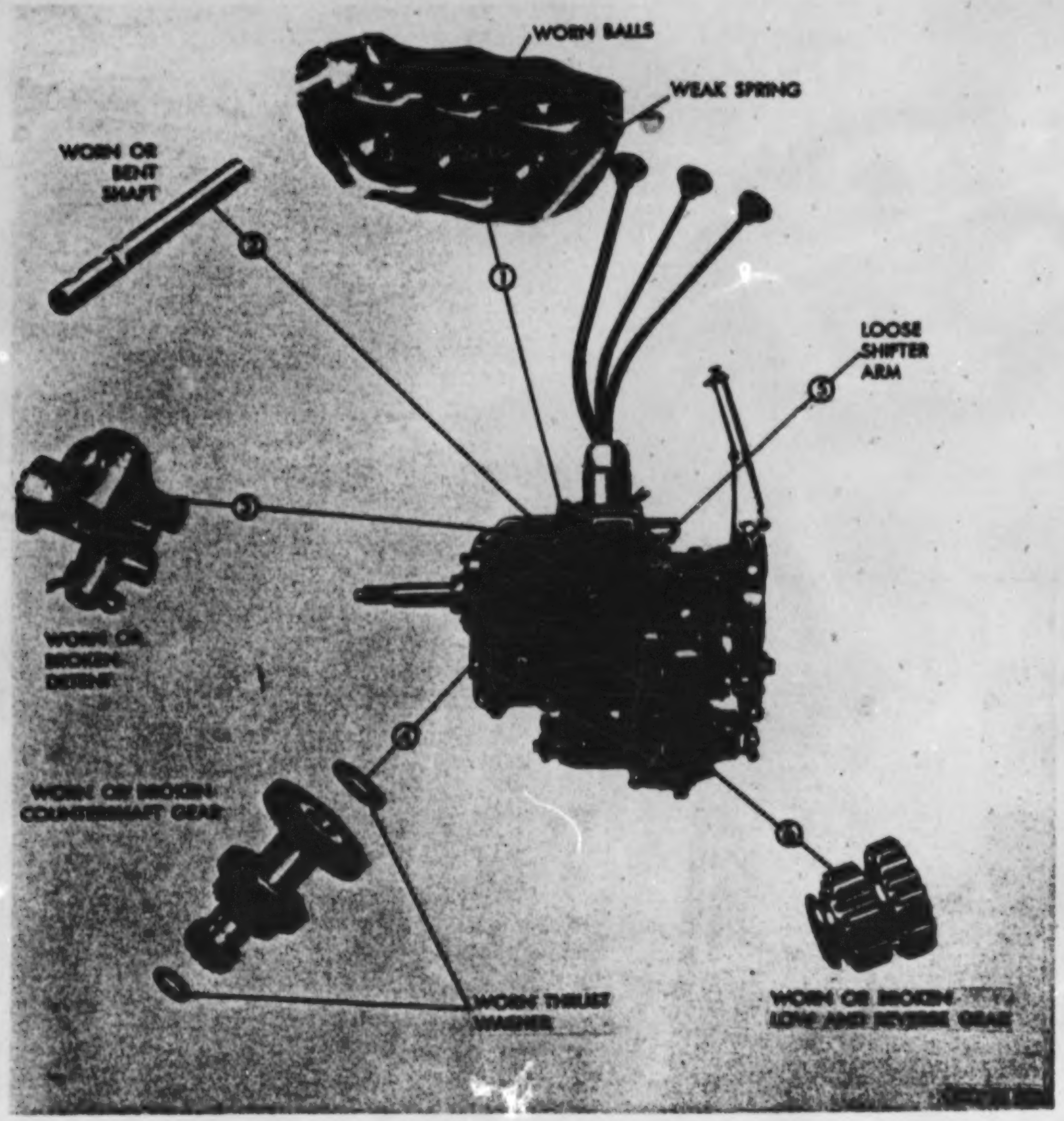


1 - Transfer shifter shaft seal
2 - Transfer front output shaft seal
3 - Transmission drain plug
4 - Transmission fill plug
5 - Input shaft retainer seal
6 - Input shaft retainer gasket
7 - Gearshift housing gasket
8 - Gearshift lever retainer
9 - Vent valve
10 - Low and reverse shifter arm pivot
11 - Shifter shaft seal
12 - Speedometer bearing sealer
13 - Transfer case retaining bolts
14 - Transfer input shaft seal
15 - Transfer rear output shaft seal
16 - Transfer drain plug
17 - Transfer case gasket
18 - Transfer shift cover plate

GEARSHIFT SLIPS OUT OF FIRST OR REVERSE

Note. - Key numbers show order in which troubles will most likely occur.

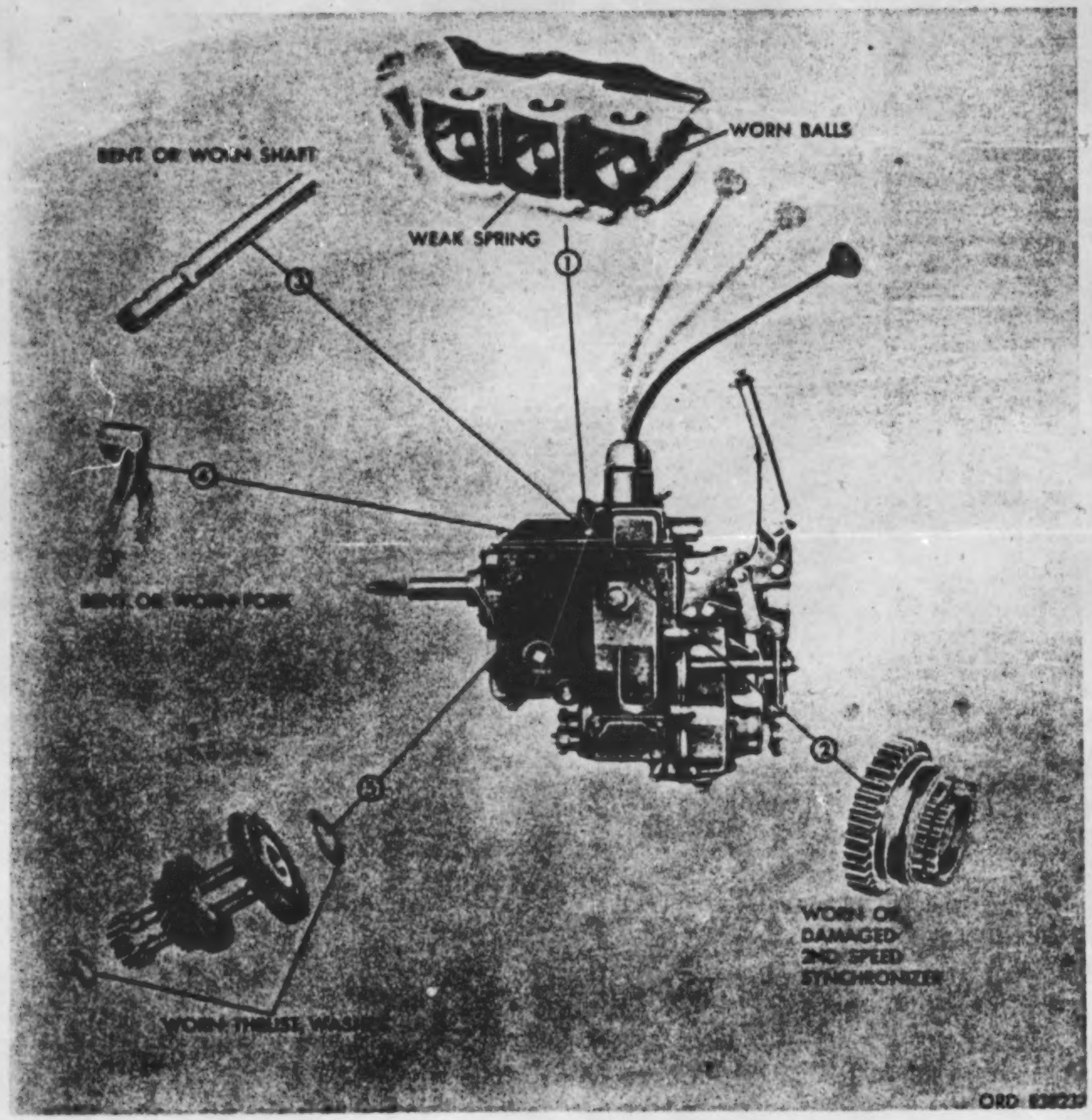
A



Foldout number 2.

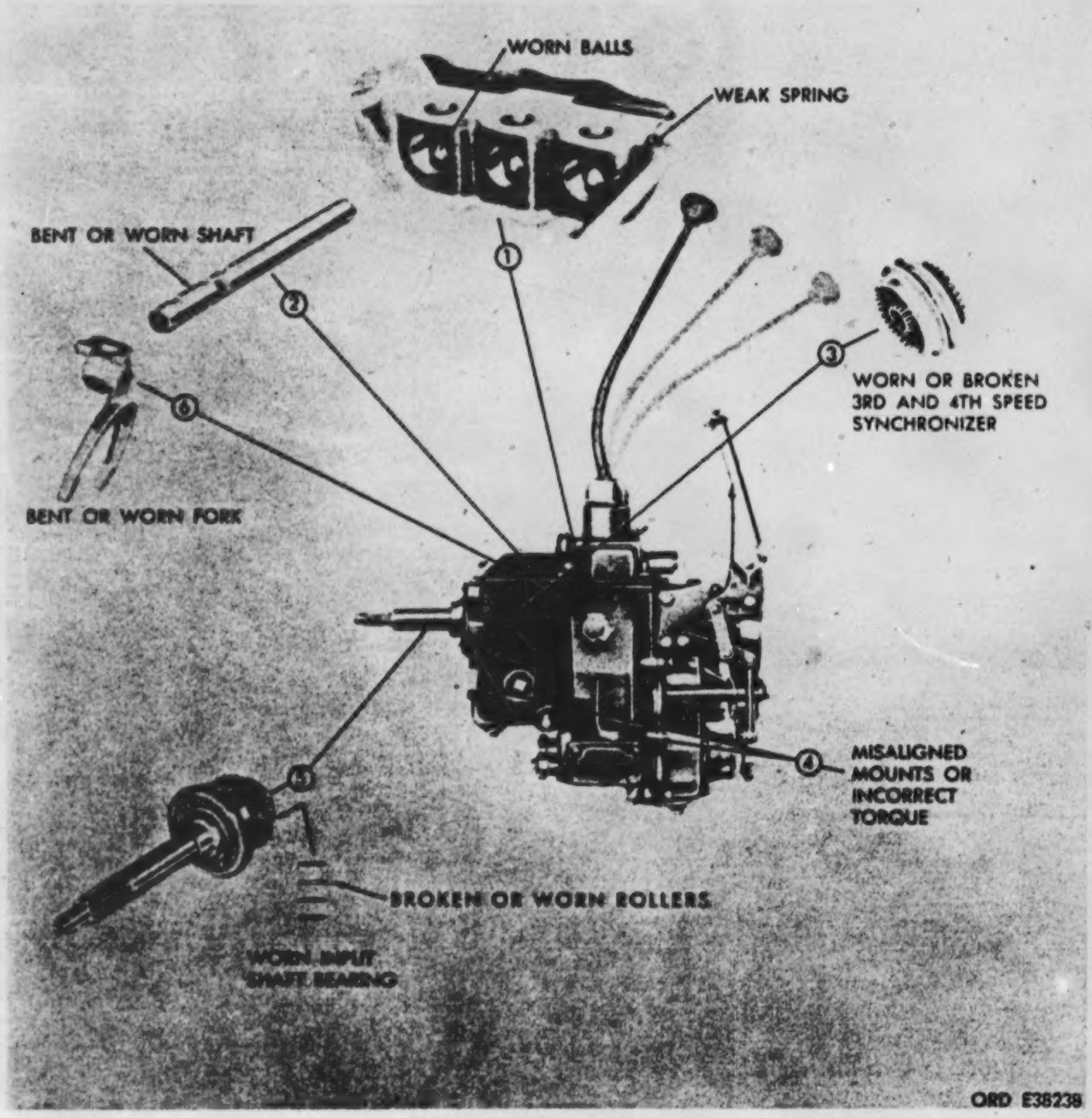
GEARSHIFT SLIPS OUT OF SECOND

Note. Key numbers show order in which troubles will most likely occur.



c152 GEARSHIFT SLIPS OUT OF THIRD OR FOURTH

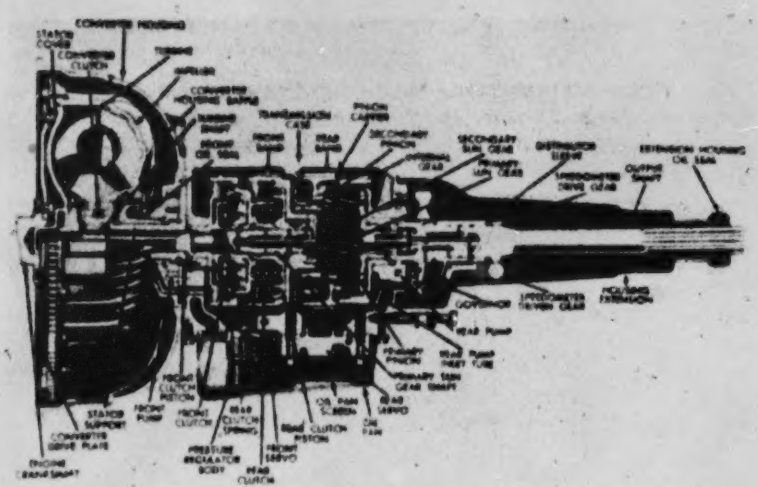
Note. Key numbers show order in which troubles will most likely occur..



ENLISTED MOS

CORRESPONDENCE/OJT COURSE

ORDNANCE SUBCOURSE 63B205



LESSON 5

WHEELED VEHICLE AUTOMATIC TRANSMISSIONS

OCTOBER 1975

DEPARTMENT OF ARMY WIDE TRAINING SUPPORT
US ARMY ORDNANCE CENTER AND SCHOOL
ABERDEEN PROVING GROUND, MARYLAND

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US ARMY ORDNANCE CENTER AND SCHOOL
CORRESPONDENCE/OJT COURSE

LESSON ASSIGNMENT SHEET

Ordnance Subcourse No 63B205	Wheeled Vehicle Clutches, Transmissions, and Transfers
Lesson 5	Wheeled Vehicle Automatic Transmissions
Credit Hours	Three
Lesson Objective	After studying this lesson you will be able to: 1. Describe the construction of fluid couplings. 2. Explain the operation of fluid couplings. 3. Describe hydramatic transmission construction. 4. Explain the operation of a hydramatic transmission. 5. Describe the procedures for inspecting the hydramatic transmission.

6. Describe the procedures for testing the hydramatic transmission.

7. Describe the procedures for adjusting the hydramatic transmission bands.

8. Describe the procedures for making a hydramatic transmissio linkage adjustment.

Text. . . . . Study Text

Materials Required . . . . Answer sheet and response list

Suggestions . . . . Refer to the illustrations while readin the text.

STUDY TEXT

FOREWORD

The performance of any vehicle and the lifespan of its engine and power train depend a great deal on the selection of the transmission gear ratios and on the smoothness of gear shifting. If the engine is run either too slow or too fast it does not develop full power, so vehicle performance is reduce At the same time, engine parts are subjected to stresses that are much greater than when the engine is running in the proper speed range, so engin wear is also increased.

With a conventional transmission it takes an experienced driver to know which gear the transmission should be shifted to in all instances. In addition, it requires a lot of skill to operate the clutch and disengage and engage the power just right so the transfer of power to the driving wheels is smooth under all conditions. Distractions created by other vehicles, confusing road signs, and road conditions can cause even the experienced driver to make an occasional mistake in gear shifting.

For many years passenger cars have had transmissions that select the correct gear ratios and make the shifts automatically. In some instances this type of transmission is also being used in trucks. Automatic transmissions prevent the inexperienced driver from making costly and sometimes dangerous mistakes in gear shifting. It frees the experienced driver from the bother of gear shifting and lets him concentrate more on other driving tasks.

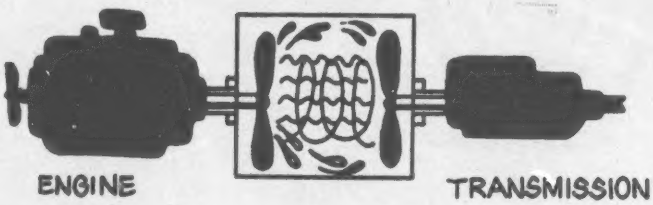
SECTION I. CONSTRUCTION AND OPERATION OF AUTOMATIC TRANSMISSIONS

1. INTRODUCTION TO AUTOMATIC TRANSMISSIONS. We commonly use the term automatic transmission in today's language. However, the term is not completely correct because there are no automatic transmissions as such. All transmissions must be manually controlled. This means that to make the transmission do its job it must be shifted by the use of a lever or a series of levers and controls. For instance, when the engine is started the lever is placed in a neutral or park position. In order for the transmission to start functioning it must be manually placed into the drive or reverse position. When this is done, the transmission is then ready to function automatically. Se we say that automatic transmissions are manually controlled and hydraulically operated. The automatic transmission we will discuss here is called the hydramatic transmission.

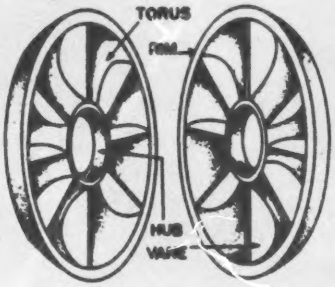
2. FLUID COUPLINGS. With conventional transmissions we studied how a disk-type clutch was used to connect and disconnect engine power from the transmission. The hydramatic transmission uses a fluid coupling between the engine and transmission. A fluid coupling uses oil for the connection between the engine power and transmission.

a. We know that wind or moving air will make a propeller spin. As the air hits the slanted portion of the blades, it causes the blades to move.

b. If we take two fans and place them so they are facing each other, they can be made to form a coupling. If one fan is turned on, the air it forces out will cause the other fan to start turning. In this case the air is the driving force.



c. A fluid coupling in its simplest form is made up of the engine flywheel, two torus members (similar to the two fans), and a cover. The two torus members are referred to as the driving and driven members. The driving member is also referred to as an impeller or pump. The driven member is commonly called the turbine.



TYPICAL FLUID-DRIVE COUPLING DRIVING AND DRIVEN TORUS (DONUT SHAPED) MEMBERS WITH STRAIGHT VANES.

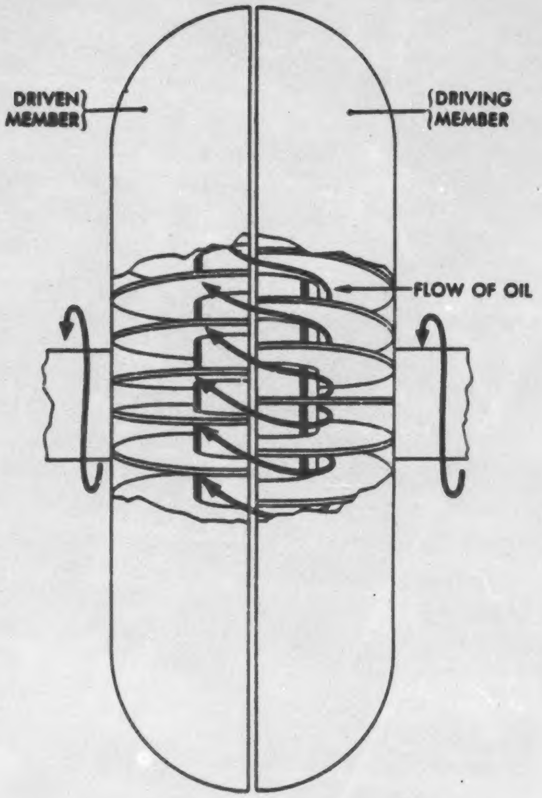
(1) When assembled, the cover is bolted to the flywheel and forms a container for the driving and driven members and oil.

(2) The driving member is mounted to the cover and rotates anytime the engine is running.

(3) The driven member is mounted on a shaft that forms the input to the transmission. It will only turn when the engine and driving members are rotating fast enough to have the oil make the driven member turn, or when the vehicle is moving whether under power or coasting.

(4) The torus members in military vehicle fluid couplings are heavy and contain many vanes. They are assembled as close together as possible without touching so that the oil is forced through the vanes at all times.

d. Now lets see how it operates. When the engine is started, the flywheel, cover, and impeller or pump turn as one unit. With the cover full of oil, the oil is thrown by centrifugal force from the center to the outside edge of the impeller between the vanes. This increases the speed of the oil movement and also increases its energy.



(1) The oil then enters the turbine vanes at the outside and flows toward the center. This causes the turbine to rotate just as air caused the fan to turn. If the turbine was connected to a shaft it could be used as the input to a transmission.

(2) Both members of the drive are much alike in their construction so that when the vehicle is coasting in gear the wheels drive the engine. In this case the oil circulates in the reverse direction. The engine can brake the vehicle as in a vehicle equipped with a conventional clutch.

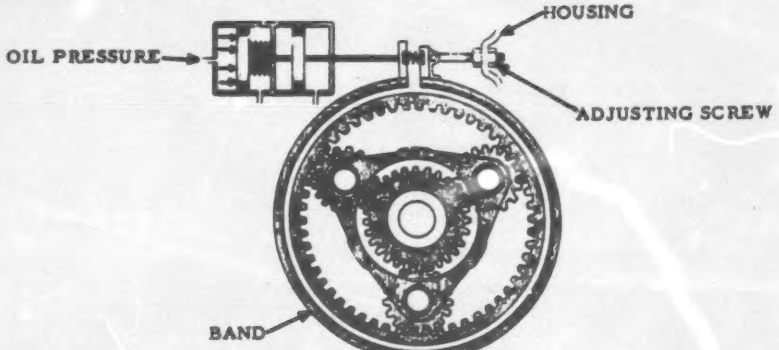
(3) When the engine is idling, the energy of the moving oil is not enough to turn the turbine if it is under load, so the fluid coupling is slipping. The amount of slip is determined by the torque required to turn the driven member. The slip is 100 percent when the vehicle is standing still and the engine is running. However, the slippage drops rapidly as the vehicle gathers speed. In some arrangements the slippage reduces to 1 percent during normal operation above 30 MPH.

(4) The main advantage of the fluid coupling is that it eliminates vibrations from the engine and provides a smooth, jerkless acceleration due to the cushioning of the fluid between the driving and driven members.

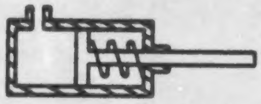
3. CONSTRUCTION OF THE HYDRAMATIC TRANSMISSION. In an earlier lesson we discussed the various types of gears and gear trains to include a simple planetary gearset. Planetary gears are used in the model 303M hydramatic transmissions. However, because the output of one planetary set is often used as the input to another set, they are called multiple planetary gear trains instead of simple planetary sets.

a. In this transmission two or more simple planetary gearsets are mounted in series, with the output of one serving as the input of the next. Each simple gearset provides two of the six gear ratios it could possibly produce. Usually it provides for a gear reduction and a direct drive. The model 303M hydramatic transmission will be used as an example in this lesson. Two planetary units are used for forward speeds, one unit for reverse, and one as a reduction unit for low range.

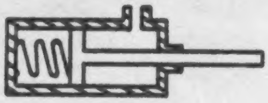
b. Bands are used to hold drums which are attached to the members to be made reactionary (held from turning). There are two bands used in the 303M transmissions: one in the front unit and one in the rear unit. The front band is wrapped around the drum which is attached to the front unit sun gear. The rear band is wrapped around the drum which is attached to the rear unit internal gear. The bands are steel straps, lined with a friction material, secured on one end to the transmission housing by an adjusting screw. The other end of the band has a bracket that is acted on by a servo to tighten the band around the drum.



c. A servo is a simple hydraulic device used to apply and release the bands. There are several types of servos which can be used. The spring released type releases the band from the drum by the pressure of a spring against a piston. The spring applied type applies the band by spring pressure against a piston. In this case the band is released by oil pressure against the opposite side of the piston. The third type servo has two apply areas. A partition in the servo serves to separate the two areas. There are various possibilities of applying and releasing a servo with two apply areas. It can be oil pressure applied and spring released, oil pressure applied and oil pressure released, or oil pressure applied and oil pressure and spring pressure released. In all of the types of servos mentioned, a stem attached to the piston moves against the band bracket to apply the band against the drum. The 303M transmission uses two servos: an oil pressure applied, oil pressure and spring released type in the front planetary unit; and a spring applied, oil pressure released type in the rear planetary unit. To increase the force applying the band a lever called an actuating lever may be used with the spring applied, oil pressure released type servo. This prevents having to use a very strong spring to apply the band.

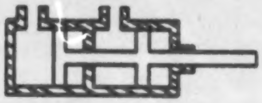


a. SPRING RELEASED

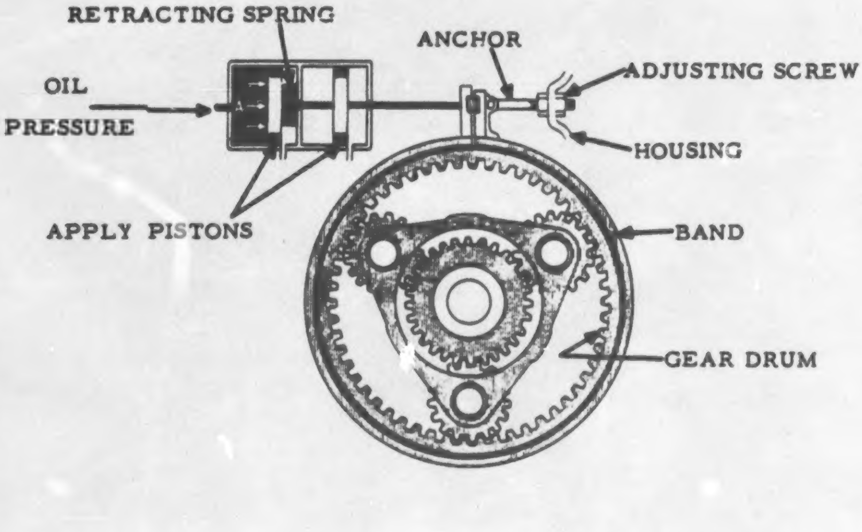


b. SPRING APPLIED

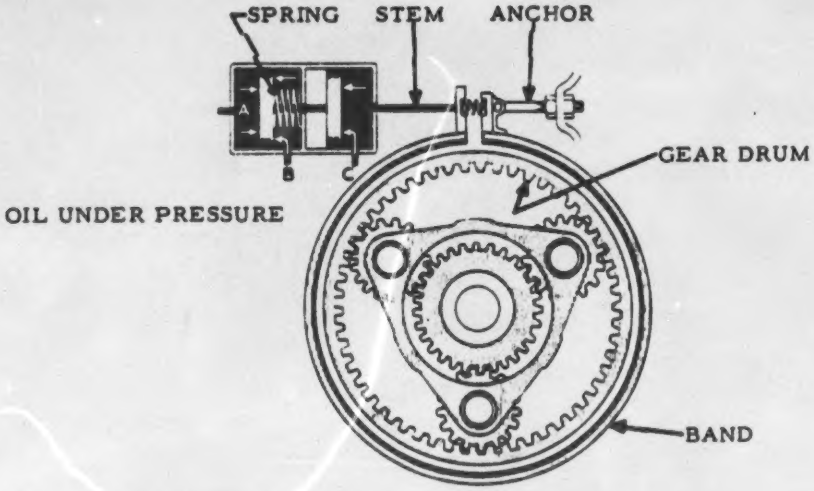
c. TWO APPLY AREAS



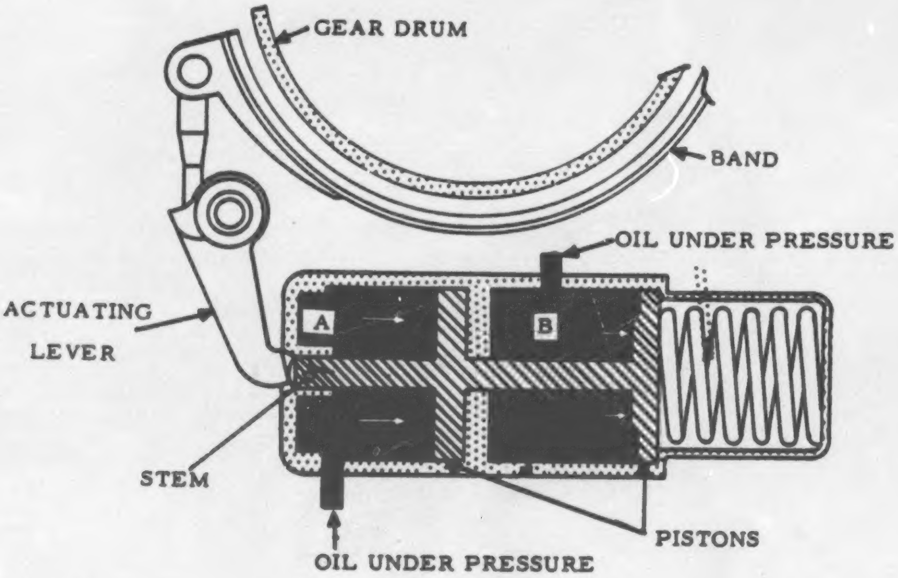
(1) Let's take a look at the operation of an oil pressure applied servo. When hydraulic force, greater than the spring pressure, is applied at point A, the piston stem will be forced against the band applying the band to the drum.



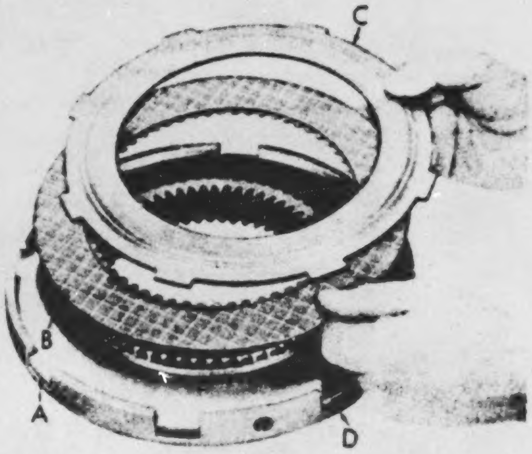
(2) When hydraulic pressure equal to that applied to point A is applied at points B and C, the piston stem will be forced away from the band because in this case pressure is applied at two areas and is assisted by the spring.



(3) The spring applied servo operates in much the same way. Hydraulic force acting on A and B overcomes the force of the band to be released. To apply the band, the oil at areas A and B is removed. The spring then moves the stem against the actuating lever applying the band against the drum.

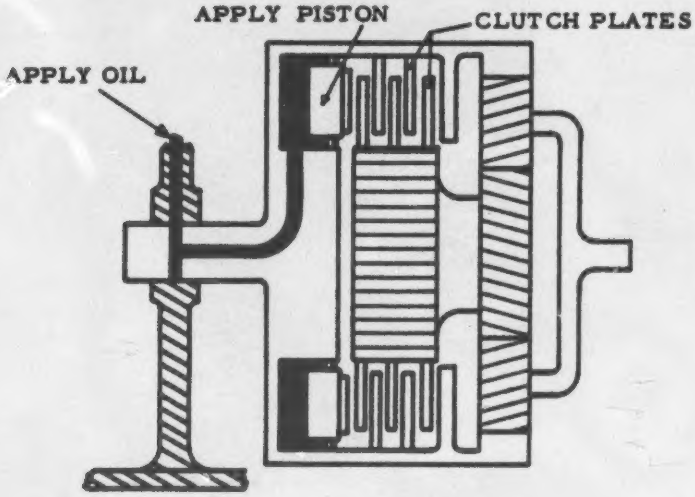


d. A multiple disk clutch is used to lock two members of the planetary gearset together to cause the set to turn as a unit, resulting in direct drive. A cone clutch is applied to a member in a planetary set to either cause a reduction or a reversing action in the transmission.

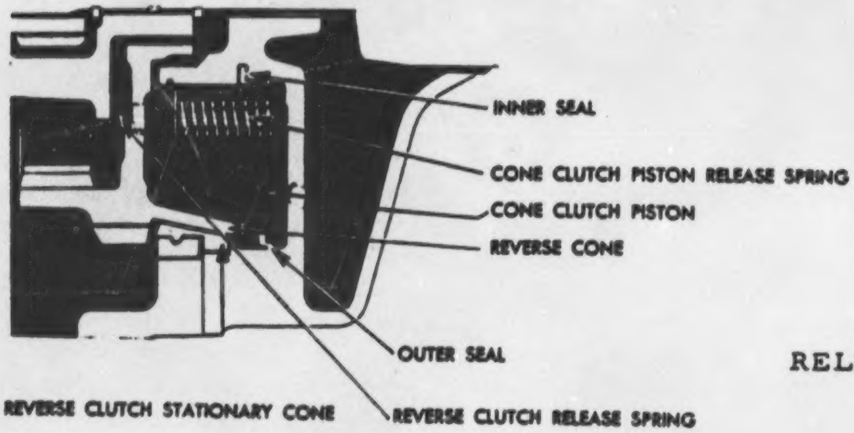


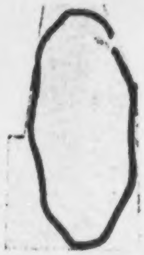
(1) The multiple disk clutch consists of driving clutch plates and driven clutch plates, a clutch apply piston, and release springs. The driving clutch plates (B) contain splines which enable them to be splined to the driving members (A) and move as the driving member moves. The driven clutch plates (C) are keyed or splined to the driven members. This enables them to drive the driven member (D).

(2) The driving and driven plates are assembled alternately. The driving plates can rotate without moving the driven plates as long as the unit is not pressed tightly together. During operation, oil under pressure flows through a passage in the shaft on which the clutch is mounted, through an oil delivery sleeve to an area behind a piston, and forces the piston against the clutch plates. The plates being squeezed together enables the driving an and driven members to move as a unit causing direct drive through the planetary unit. When the oil pressure against the piston is removed, the release springs cause the plates to again move apart and rotate independently, unlocking the planetary members. The 303M hydramatic transmission contains three multiple disk clutch assemblies: one is located in the front planetary unit, one in the rear unit, and one in the reduction unit.



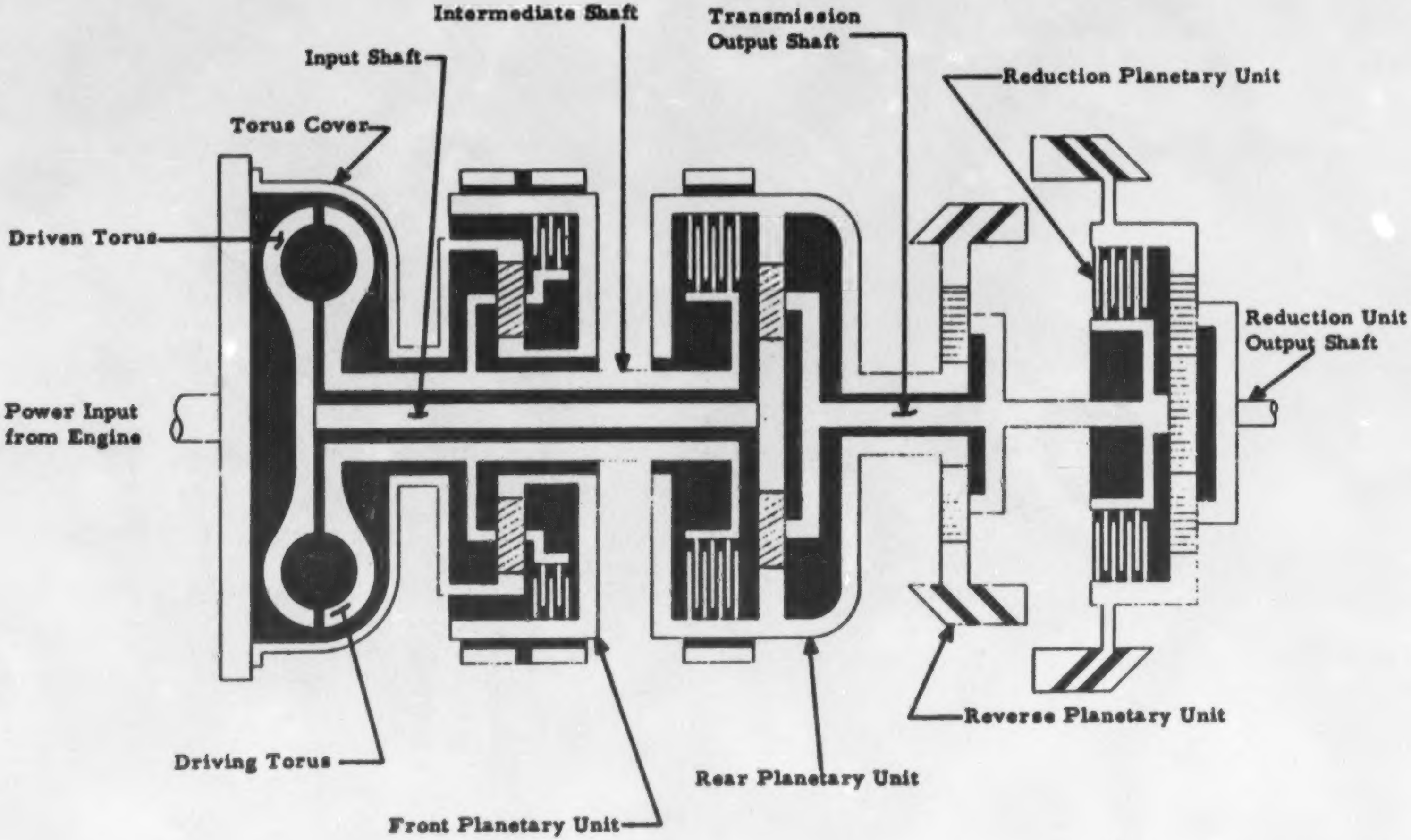
(3) A cone clutch consists of a driven and a stationary clutch cone, clutch piston, and release spring. The stationary cone is anchored to the transmission housing. One end of the driven cone is attached to the planetary member to be held, and it extends in the form of a cone to fit the stationary cone and the clutch piston. In operation, oil pressure is sent into a chamber behind the piston forcing the piston to press against the driven cone. The driven cone in turn is bound against the stationary cone, holding the planetary member stationary. When the oil pressure behind the piston is removed, the piston release springs cause the piston to move out of engagement with the driven cone. At the same time, a clutch release spring disengages the driven cone from the stationary cone, unlocking the planetary member. The 303M transmission contains two cone clutches: one cone clutch is located in the reverse unit and one in the reduction unit of the transmission.


INNER SEAL
CONE CLUTCH PISTON RELEASE SPRING
CONE CLUTCH PISTON
REVERSE CONE
OUTER SEAL
REVERSE CLUTCH STATIONARY CONE
REVERSE CLUTCH RELEASE SPRING



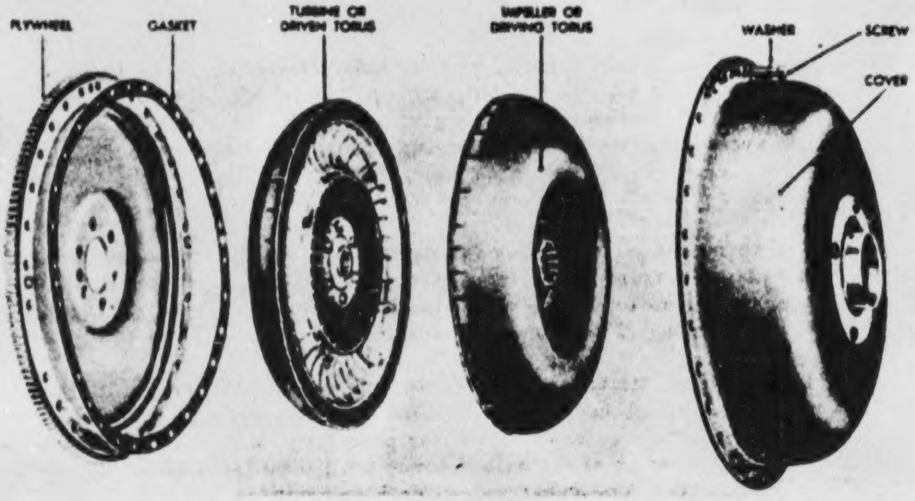
CLUTCH RELEASE SPRING

e. Now let's see how some of these components are connected together and also review a little of their construction. The 303M transmission consists mainly of a fluid coupling, front planetary unit, rear planetary unit, reverse planetary unit, and a reduction planetary unit. Connecting these units in the transmission are four different shafts. These include the input shaft, intermediate shaft, transmission output, and the reduction unit output shaft.


Intermediate Shaft
Transmission Output Shaft
Input Shaft
Reduction Planetary Unit
Torus Cover
Driven Torus
Reduction Unit Output Shaft
Power Input from Engine
Reverse Planetary Unit
Driving Torus
Rear Planetary Unit
Front Planetary Unit

5-11

(1) The fluid coupling consists of a torus cover attached to the engine flywheel, a driving torus which is connected to the intermediate shaft, and a driven torus which is connected to the main shaft.



(2) The front planetary consists of a ring gear assembly which is connected to the torus cover of the fluid coupling, a planet carrier connected to the intermediate shaft, and a sun gear drum assembly. A double wrap band is located on the sun gear drum. The unit contains a multiple disk clutch, which has its driving disks splined to the planet carrier and the driven disks keyed to the sun gear drum assembly.

(3) The rear planetary unit consists of a ring gear drum assembly which is connected to the sun gear of the reverse unit, and a sun gear which is connected to the input shaft. A single wrap band is located on the ring gear drum assembly. The unit contains a multiple disk clutch, which has its driving disks splined to a clutch hub connected to the intermediate shaft and the driven disks keyed to the ring gear drum assembly.

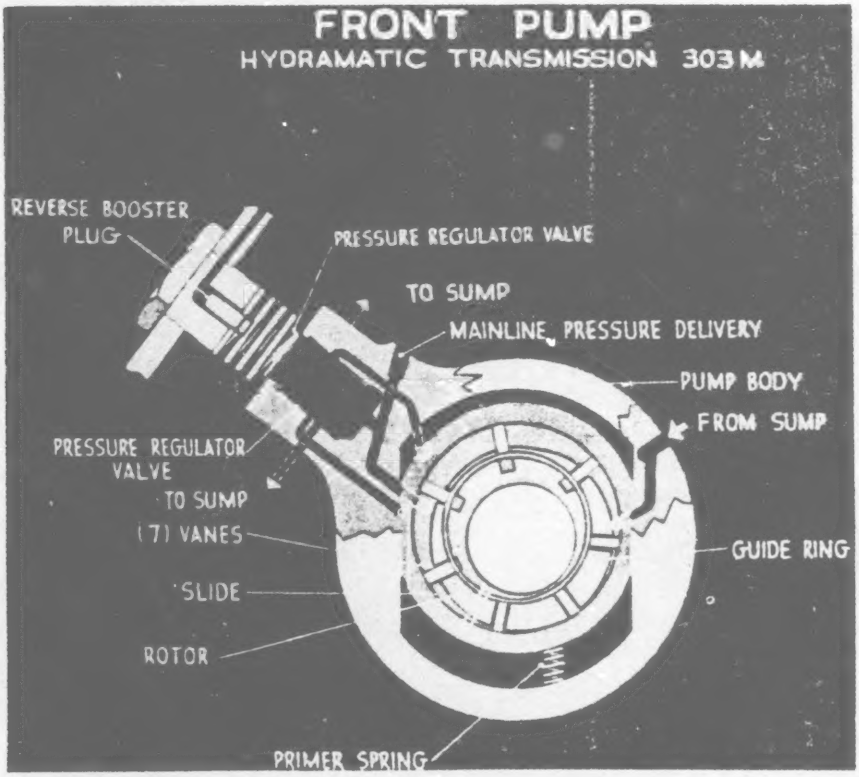
(4) As mentioned in the previous paragraph, the sun gear of the reverse planetary unit is connected to the ring gear assembly of the rear planetary unit. The planet carrier is connected to the transmission output shaft. The ring gear assembly can be locked to the transmission housing by a cone clutch.

(5) The reduction unit contains a multiple disk clutch hub assembly, which is connected to the transmission output shaft on which the driving disks are splined. The driven disks are keyed to a ring gear assembly. A cone clutch locks the ring gear assembly to the reduction housing. The sun gear of the reduction unit is connected to the transmission output shaft, while the planet carrier is connected to the reduction unit output shaft.

4. **HYDRAULIC AND LUBRICATION SYSTEM.** So far we have discussed some of the mechanical components of the transmission and some of the hydraulically operated components. However, there are more components of the hydraulic system.

a. There are three oil pumps used in this transmission: the front, rear, and reduction oil pumps.

(1) The front oil pump is located in the front of the transmission case. It is driven by the front planetary unit internal gear which is connected to the torus cover and is driven at engine speed. The front pump draws oil from the transmission oilpan and supplies oil for the operation and lubrication of the transmission when the vehicle is standing with the engine running. When the vehicle is moving, the front pump works with the reduction unit oil pump to supply oil to the transmission.



(2) The rear oil pump is a reversible-type pump. It is located behind the rear planetary unit and is much larger than the other pumps. It is gear driven from the transmission output shaft, so it can only operate when the vehicle is in motion. It pulls oil from the reduction unit case and delivers it to the oilpan sump.

(3) The reduction unit oil pump is also a reversible-type pump that only operates when the vehicle is moving. In addition to being able to supply oil to the transmission when the vehicle is in operation, it can also supply oil to operate the components when the vehicle is being started by towing.

b. The operation of the hydraulic components in the transmission is controlled by the transmission control valve assembly. This assembly consists mainly of two valve bodies: an inner body and an outer body. The inner body contains three shift valves, regulator plugs, and governor plugs. The outer body contains a manual valve, throttle valve, detent plug, T-valve, double transition valve, compensator valve, and an exhaust valve.

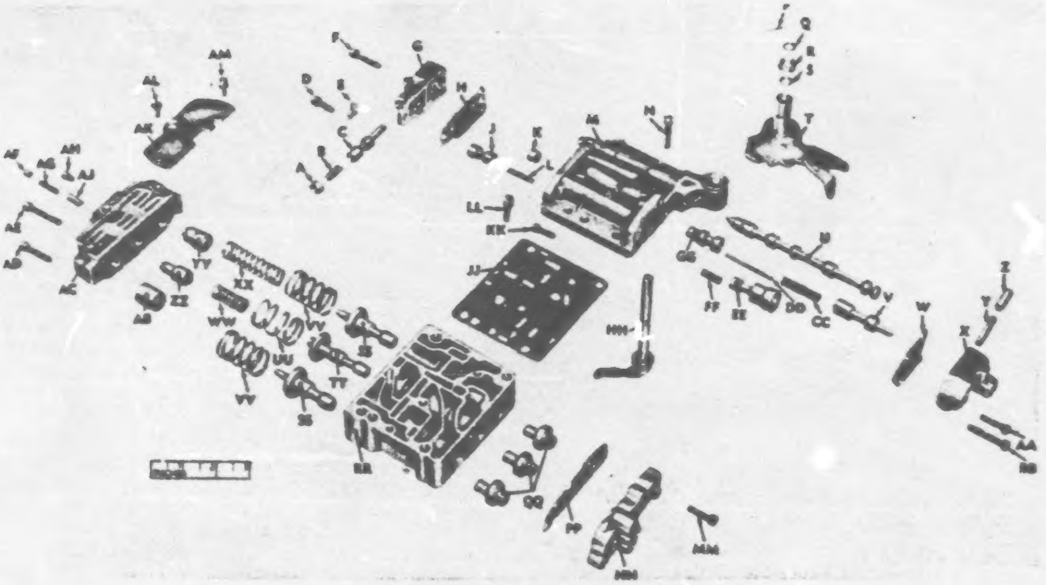
(1) The shift valves direct oil from the manual control valve to apply the bands and clutches in the proper sequence to upshift and downshift the transmission.

(2) The manual control valve is connected with the transmission shift control lever by linkage and may be moved to any of four positions: N (neutral), F1, F2, or R (reverse).

(3) The throttle valve is used to delay upshifts and to force downshifts. It is operated by linkage from the accelerator pedal.

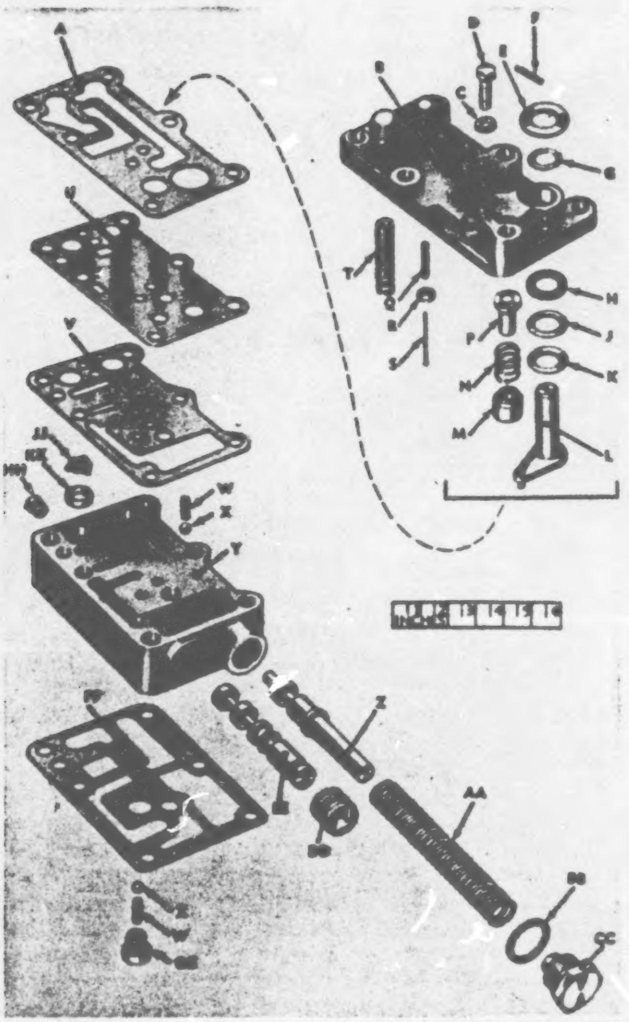
c. The transmission governor, driven by a worm gear on the transmission output shaft, is used to supply oil at a variable pressure to operate the shift valves.

d. The reduction control valve assembly controls the operation of the reduction unit direct drive clutch and the cone-type reduction clutch. It is operated through linkage from the transmission shift control lever.



A—Exhaust body hole plug YT-8613832
B—Exhaust body valve spring YT-8613833
C—Exhaust body valve YT-8613834
D—No. 10 x ⅝ screw w/lockwasher 454027
E—Exhaust body valve spring retainer YT-8613858
F—No. 10 x 1 screw w/lockwasher 454028
G—Exhaust body YT-8613831
H—Exhaust body plate YT-8613857
J—Compensator valve YT-8614012
K—Throttle valve plug YT-8614002
L—Compensator valve spring A410036
M—Outer body 8333710
N—No. 10 x 1⅛ screw w/lockwasher 454031
P—Throttle valve control lever shaft retaining pin 187381
Q—Throttle valve control lever shaft retaining pin washer 8328349
R—Throttle valve control lever shaft seal retainer 8328348
S—O-ring gasket 501219
T—Manual control valve lever assembly 7412625
U—Manual control valve 7411503
V—"T" valve YT-8614013
W—Detent plunger retainer spacer YT-8614004
X—Detent plunger retainer YT-8614000
Y—Detent plunger spring 7410981
Z—Detent plunger 7410978
AA—No. 10 x ¾ screw w/lockwasher 454029
BB—No. 10 x 1⅛ screw w/lockwasher 454031
CC—Throttle valve spring YT-8614006
DD—"T" valve transfer pin YT-8614020
EE—Double transition valve YT-8614010
FF—Double transition valve spring YT-8617066
GG—Throttle valve YT-8614009
HH—Throttle valve control lever w/shaft YT-8614015
JJ—Inner and outer body spacing plate YT-8614089
KK—No. 10 x ⅝ screw w/lockwasher 454027
LL—No. 10 x ¾ screw w/lockwasher 454029
MM—No. 10 x ¾ screw w/lockwasher 454029
NN—Inner body cover YT-8613999
PP—Inner body cover plate YT-8613578
QQ—Governor plug 7084173
RR—Inner body YT-8614014
SS—2-3 and 3-4 shift valve YT-8613379
TT—1-2 shift valve YT-8613380
UU—1-2 shift valve spring YT-8613865
VV—2-3 and 3-4 shift valve spring YT-8613867
WW—1-2 shift valve regulator plug spring YT-8613864
XX—2-3 shift valve regulator plug spring YT-8613866
YY—2-3 shift valve regulator plug YT-8614103
ZZ—1-2 shift valve regulator plug 7084174
AB—3-4 shift valve regulator plug A262296
AC—Front body YT-8613997
AD—No. 10 x 1 screw w/lockwasher 454028
AE—No. 10 x 1¼ screw w/lockwasher 190163
AF—Front body hole plug YT-8614088
AG—"T" valve cutoff valve spring YT-8614242
AH—No. 8 x 5/16 screw 110809
AJ—"T" valve cutoff valve
AK—Front body plate
AL—No. 10 x ⅜ screw
AM—No. 10 x 7/16 screw w/lockwasher

Transmission control valve components.

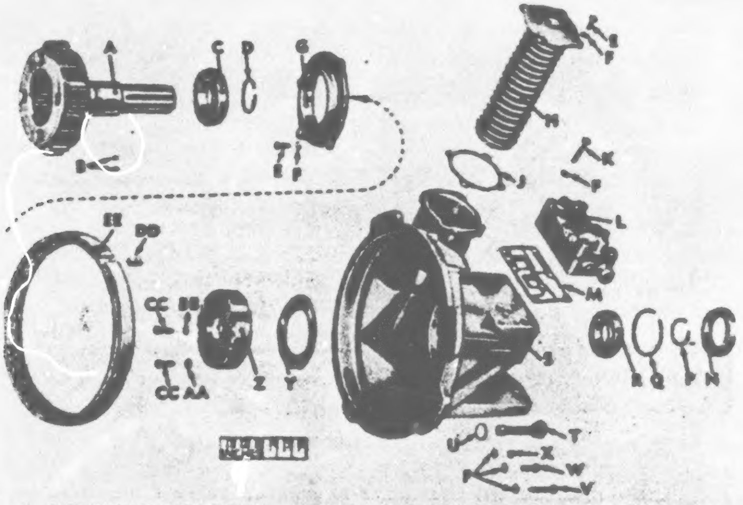


A—Cover gasket 7411457
B—Cover YT-8613681
C—¼-Inch lockwasher 103319
D—¼ x 1 Bolt 100110
E—Control lever washer 7411473
F—Control lever pin 443127
G—O-Ring gasket 501223
H—Control lever inner seal A327516
J—Control lever outer washer A327514
K—Control lever inner washer A327515
L—Control lever assembly 7411461
M—Reduction blocker piston retainer YT-86140[illegible]
N—Reduction blocker piston inhibitor spring YT-8614033
P—Reduction blocker piston YT-8614039
Q—Cover check valve spring A410036
R—Cover check valve A262254
S—Cover check valve guide pin YT-8613587

T—Accumulator check valve spring 7411466
U—Body spacer plate YT-8613686
V—Body spacer plate gasket 7411458
W—Detent ball spring 7411467
X—Detent ball 169108
Y—Body YT-8613669
Z—Pressure regulator valve 7411472
AA—Pressure regulator valve spring 7411468
BB—Pressure regulator valve stop plug washer 7411456
CC—Pressure regulator valve stop plug 7411261
DD—Body plug YT-8614229
EE—Reduction control valve 7411471
FF—Reduction unit control valve gasket 7411459
GG—Detent ball spring retaining plug 7411463
HH—⅛-Inch pipe plug 103883
JJ—Accumulator check valve 7411470
KK—Accumulator check valve seat 7411465

Reduction unit control valve components.

e. The accumulator assembly is located on the reduction unit case. Its purpose is to furnish enough oil at a pressure high enough to apply the reduction unit clutches.



A—OUTPUT SHAFT ASSY—7411669
B—OIL PUMP DRIVE KEY—7084021
C—OUTPUT SHAFT FRONT BEARING—700083
D—SNAP RING—7411660
E—3/8 X 1 BOLT—272491
F—3/8-INCH LOCK WASHER—103321
G—OUTPUT SHAFT FRONT BEARING SUPPORT —7411672
H—ACCUMULATOR ASSY—7411367
J—COVER GASKET—7411436
K—3/8 X 2-3/4 BOLT—272492
L—CONTROL VALVE ASSY—7411469
M—CONTROL VALVE GASKET—7411459
N—OUTPUT SHAFT OIL SEAL ASSY—7411666
P—SNAP RING—7411663
Q—SNAP RING—7411661
R—OUTPUT SHAFT REAR BEARING—700125
S—CASE—7411448
T—DRAIN PLUG—YT-8614227
U—DRAIN PLUG GASKET—120428
V—3/8 X 2-1/4 BOLT—7412626
W—3/8 X 1-1/4 BOLT—272489
X—3/8-24 NUT—103026
Y—OIL PUMP GASKET—7411435
Z—OIL PUMP ASSY—7411437
AA—1/4-INCH LOCK WASHER—1[illegible]
BB—9/32-INCH COPPER FLAT WASHER—116102
CC—1/4 X 1-3/4 BOLT—272490
DD—STATIONARY CONE KEY ASSY—7411654
EE—STATIONARY CONE—7411469

SECTION II. MAINTENANCE OF THE HYDRAMATIC TRANSMISSION

5. INSPECTION. Before any tests are made on the transmission, check the oil level to make sure it is not too high or too low. The transmission dipstick is located in the oil filler tube. The dipstick has two level marks: COLD FULL as the lower mark, and HOT FULL as the upper mark. The cold full mark is used for checking the transmission oil level when the vehicle has not been run for a long period of time. The hot full is used when the engine and transmission has been run long enough to reach operating temperature. The transmission oil level is checked with the engine running and the transmission in a forward speed range. The engine must remain at an idle speed with the parking brake firmly applied. As a further precaution no one should be in front of the vehicle while the oil level check is being made.

a. To check the transmission if it has not been run for a long time, apply the parking brake and start the engine. Move the transmission control lever into the F1 high-range position (forward) and run the engine at idle speed for 3 to 5 minutes. Lift the floor plate in the driver's cab to get to the transmission dipstick. Be sure and clean away any dirt that might drop into the dipstick hole when it is pulled out. Now with the engine still running, pull out the dipstick, wipe it off with a clean rag, and stick it back into the dipstick hole. Pull it out again and look at the oil level on the dipstick. It should be about at the COLD FULL mark on the dipstick.

b. When the vehicle has been run for a long time and the engine and transmission are at normal operating temperatures, stop the vehicle, apply the parking brake, and move the control lever to F1 high range. Let the engine idle for 3 to 5 minutes. Using the same procedure as above, the oil level should be about at the HOT FULL mark on the dipstick.

c. To replenish the transmission oil, place the transmission control lever in the N (neutral) position, apply the parking brake, and start the engine. Now move the transmission control lever into the F1 high-range position. As before, clean off any dirt that is around the filler cap. Remove the filler cap and dipstick. Add enough oil to bring the oil level up to the reading on the dipstick, depending on whether the transmission is hot or cold. Do not overfill the transmission as this causes heating and foaming of the oil which, in turn, will cause either too fast or too slow shifting and will also cause oil leakage.

d. The hydramatic transmission does not burn or use oil as an engine does. If the transmission oil level is found to be low at different times when it is checked, the cause will be leakage. The reason for the leakage must be found and corrected or serious damage will result to the transmission.

(1) Leakage checks of the flywheel and torus cover are as follows: Remove the eight capscrews and lockwashers that attach the flywheel housing cover to the flywheel housing and remove the cover. Now use a drycleaning solvent and wash the flywheel and torus cover thoroughly, then dry them completely. Next, spread a clean piece of white or brown paper under the flywheel and torus cover. Now with the transmission control lever in the N (neutral) position, start the engine and run it at a speed of 700 RPM for several minutes or until the oil spray marks appear on the paper, then stop the engine. At this time check for leaks in the line with the spray marks on the paper. Also, check carefully at the flywheel and torus cover for any sign of oil leakage.

(2) If oil is streaked along the front face of the flywheel, the leakage is between the flywheel and the crankshaft. If oil is streaked along the torus cover, the leakage is occurring in one or more of the following areas: between the torus cover neck and the oil seal, the front pump cover and the transmission case, at the torus cover dampener rivets, or from the front pump cover to the body bolts. If the flywheel or torus cover is not streaked with oil, the leakage may be at the joint between the flywheel and the torus cover.

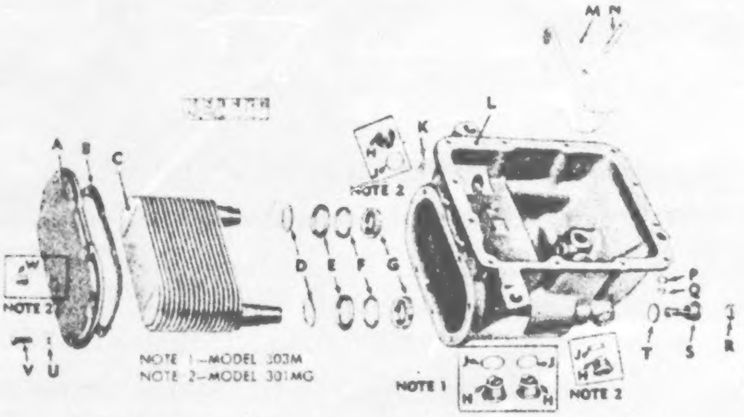
(3) If leakage is found at the torus cover drain plug, first tighten the drain plug. If there is still leakage after tightening the drain plug, remove the plug, drain the fluid coupling, and add a thin coating of gasket cement to the threads of the plug. Install and tighten the plug 15 to 18 foot-pounds of torque and refill the transmission to the proper oil level.

(4) For oil leaks of the transmission pan, first check for loose oil pan to transmission case attaching capscrews and nuts. If any are found to be loose, tighten them to 10-13 lb-ft of torque. If the leakage continues in this area, the cause may be a defective oilpan to transmission case gasket. If this is the cause of the leakage, replace the gasket.

(5) For oil leaks of the transmission side cover, check the oil pressure test plug, pressure regulator plug, and the external oil line fittings for any looseness. Tighten any loose parts as necessary. Also check for loose transmission side-cover-to-case attaching capscrews. If the capscrews are found to be loose, tighten them to 12-15 lb-ft of torque. If the leakage is from the reduction unit drain plug, check first to see if the plunger is loose. Tighten the plug to 35-45 lb-ft of torque. If there is still leakage after tightening the plug, remove the plug, put on a new plug gasket, reinstall, and retorque to 35-45 lb-ft. If a leak is found between the rear bearing retainer and the reduction unit case gasket area, the transmission will have to be taken apart to repair it.

(6) If leakage at the reduction unit control valve assembly is seen around the reduction unit pressure regulator valve plug, tighten the plug to 35-45 lb-ft of torque. If the leak continues after tightening, remove the plug, install a new fiber washer, reinstall, and tighten the plug to 35-45 lb-ft of torque. If a leak is found at the manual control, valve stop pipe plug, tighten the plug to 25-30 lb-ft of torque.

e. Use the following procedures to check for internal water leaks. If the transmission oil level is found to be high at different checking periods, the cause may be water leaking from the cooler core inside of the transmission. This cooler is a small radiator-type device that gets its coolant from the engine cooling system. It is located in the bottom and inside of the transmission. As the transmission oil gets hot, the cooler carries away the heat from the oil.

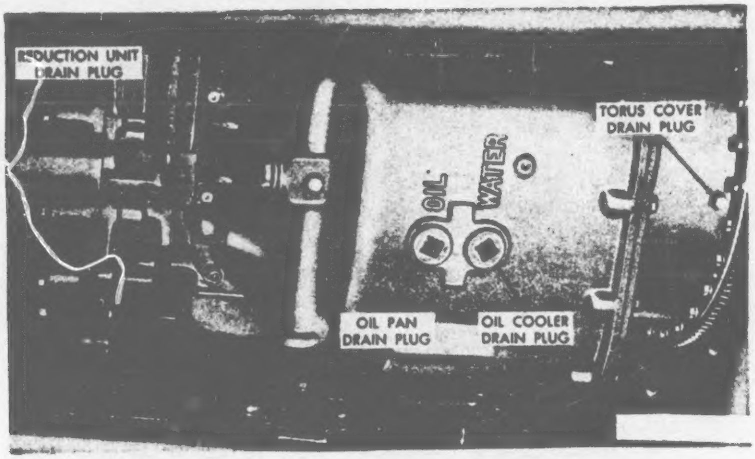


A—OIL COOLER COVER—6293549 (303M) —YT-8615133 (301MG)
B—OIL COOLER COVER GASKET—6293551 (303M)—YT-8605091 (301MG)
C—OIL COOLER ASSY—5608479
D—OIL COOLER MOUNTING GASKET—5342367
E—OIL COOLER MOUNTING NUT ADAPTER RING SEAL—5342366
F—OIL COOLER MOUNTING NUT ADAPTER RING—5342364
G—OIL COOLER MOUNTING NUT—5342365
H—MAGNETIC DRAIN PLUG—7376357
J—DRAIN PLUG GASKET—120428
K—5/16 X 3/4 CAP SCREW W/COPPER WASHER—5293626
L—OIL PAN ASSY—7411445 (303M) —YT-8615[illegible] (301MG)
M—OIL PAN OIL SCREEN ASSY—7411446
N—OIL SCREEN BOLT—5410070
P—11/32-INCH COPPER WASHER—115308
Q—5/16-24 NUT—103025
R—BY-PASS VALVE CAP—7002496
S—BY-PASS VALVE ASSY—5266340
T—BY-PASS VALVE GASKET—5262474
U—5/16-INCH LOCK WASHER—103320
V—5/16 X 7/8 BOLT—179817
W—1/4-INCH SQUARE HEAD DRAIN PLUG—444734

(1) A check can be made by draining a small quantity of oil from the transmission. Look at the oil to see if any water has gotten into it. If you will recall in the lesson on liquid cooling systems, we told you that if the oil had a cream color there was water in the oil. If water has gotten into the oil, the transmission must be taken apart for repairs. If no water is found in the oil, refill the transmission to the proper level.

(2) If water leakage is found at the cooler core cover, the cause may be loose cover-to-transmission-oilpan attaching capscrews or a defective cover-to-oilpan gasket. Tighten the cover-to-oilpan capscrews to 15-18 lb-ft of torque. If you still have a leak, remove the eight attaching capscrews and lockwashers. Now remove the cover and its gasket. Throw the gasket away and clean the cover and the oilpan mating surfaces. Place a new gasket on the cover and secure the cover with the eight capscrews and washers. Tighten the capscrews to 15-18 lb-ft of torque.

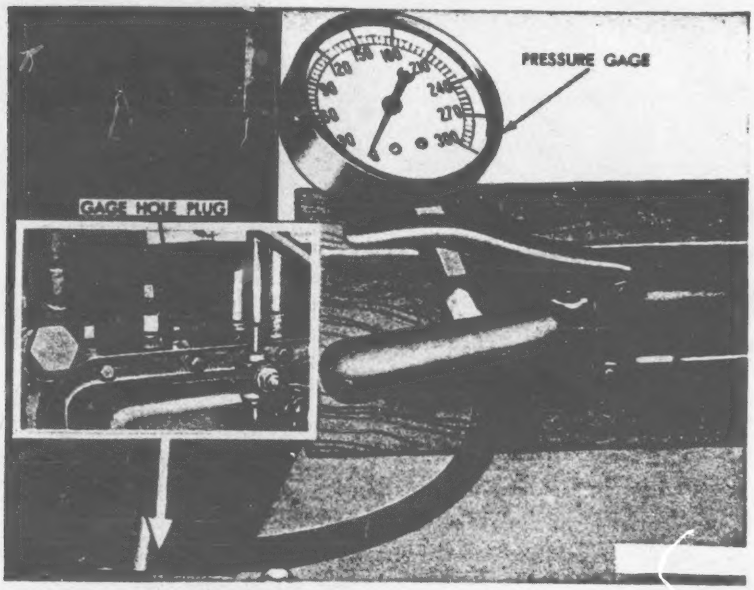
(3) Check the oilpan water drain plug to see if it is leaking water. If it is leaking, tighten the drain plug to 35-45 lb-ft of torque. If it still leaks after tightening, remove the plug, put on a new plug gasket, reinstall the plug and new gasket, and tighten to 35-45 lb-ft of torque. Refill the engine cooling system.



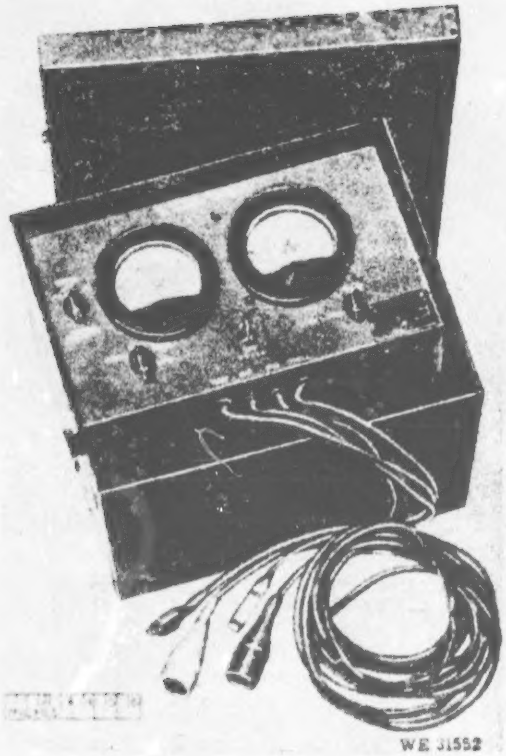
6. TESTING. The most common test you will make is the stall speed test of the 303M hydramatic transmission. Stall speed is that speed which allows the greatest number of engine revolutions per minute with the transmission in gear and the vehicle stationary. The test is performed in the following manner: The oil level and oil pressure must be checked and corrected if necessary. The wheels are blocked and the brakes set. Both the engine and transmission must be allowed to reach normal operating temperature with the transmission in neutral. Now with the engine speed at wide open throttle, check the following four positions: F1, high range; F1, low range; reverse, high range; and reverse, low range. If the transmission is operating at normal efficiency, the engine should have a minimum reading of 1,550 RPM and a maximum reading of 1,750 RPM in the four speeds. If the engine speeds are quite a bit below 1,550 RPM, the engine is probably not developing full power and should be tuned. If the engine speeds are above 1,750 RPM, the transmission is operating at less than normal efficiency and slippage inside of the transmission is indicated.

a. The following tools or gages are used to make the oil pressure tests: a pressure gage having a range from 0 to 300 PSI and a tachometer dwellmeter test set. In oil pressure tests, the first test will be with the vehicle standing.

(1) First lift the floor plate to get to the pressure takeoff pipe plug, which is located on top of the transmission case between the front and rear band adjusting screws. Remove the pressure takeoff pipe plug. Now install the adapter of the pressure gage into the hole in the transmission case where the pipe plug was removed. Leave the gage on the floor of the truck cab.



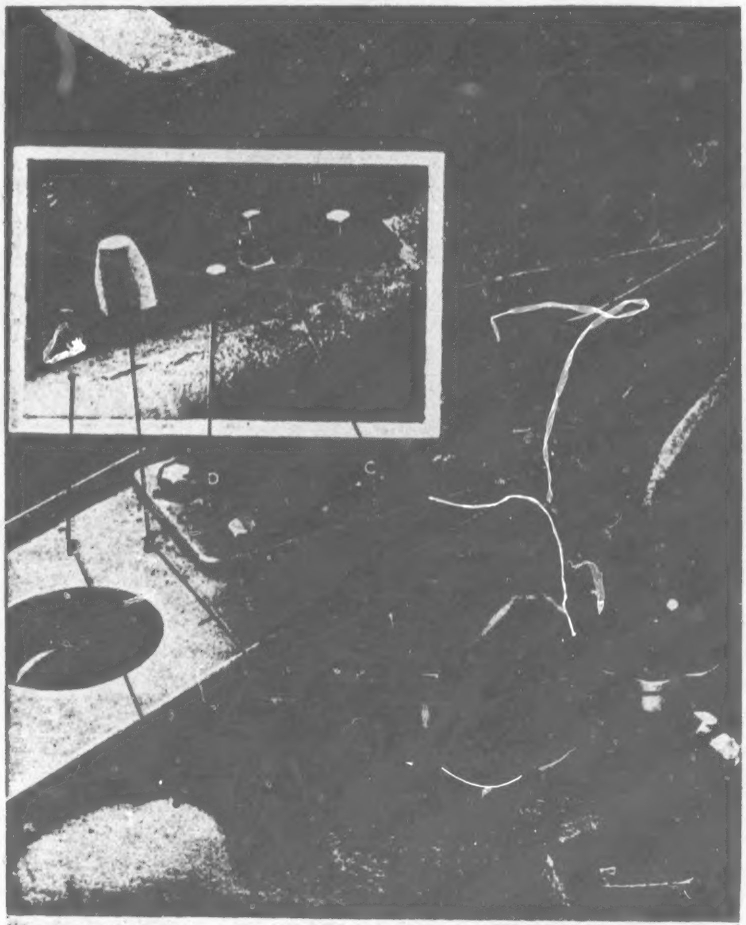
(2) Unscrew the small screw from the top of the engine distributor cover and thread a tachometer adapter into the hole. Next, connect an electric tachometer to the adapter. Start the engine and warm it and the transmission up to normal operating temperatures. With the truck standing still and the parking and foot brakes applied, speed the engine up until a 1,000 RPM reading is reached on the tachometer. Move the transmission control lever into all four high-range positions (N, F1, F2, and R) and into N (neutral) in the low-range position. When the transmission oil is warm, the oil pressure should be 95 to 110 PSI in all positions except reverse. The reverse pressure should be 180 to 220 PSI.



b. The oil pressure should also be checked while the vehicle is in motion. To do this test, use the electrical tachometer and the oil pressure checking gage to check the oil pressure reading after each upshift as the vehicle moves down the road. The pressure will be less at the instant the shift is made, but it should return to normal after the shift is completed. Be sure you have a competent driver behind the wheel as you watch the oil pressure gage for correct readings.

c. To make the reduction unit oil pump pressure test with the pressure gage installed, have your driver move the truck forward at a speed of about 30 miles per hour, then move the transmission control into neutral high-range position. As the driver turns off the ignition switch, note the reading on the pressure gage as the vehicle is coasting. The pressure should be between 95 and 110 PSI. If the pressure is lower than 95 PSI. the probable cause is a faulty reduction unit oil pump.

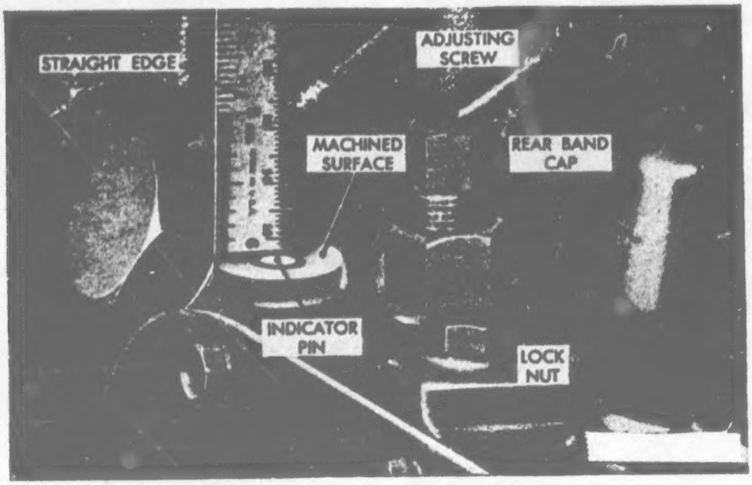
7. BAND ADJUSTMENTS. To make a front band adjustment, first fold back the companion seat. On late-type vehicles only, remove the four bolts that attach the footrest to the floor, and then remove the foot rest. Remove 14 bolts attaching the floor pan to the cab floor and dash, then remove the floor pan to gain access to the front band adjusting screw (item c). Apply the parking brake.



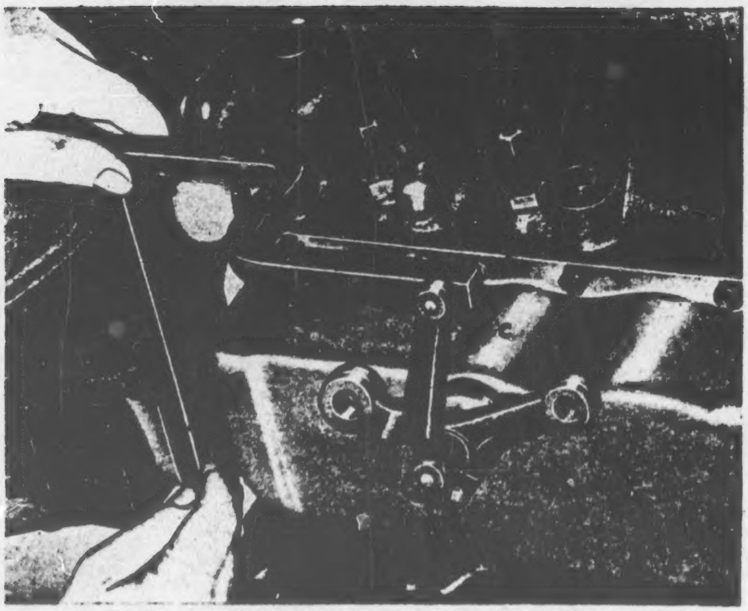
A—LOCK NUT
B—INDICATOR PIN PLUG
C—ADJUSTING SCREW
D—OIL PRESSURE PLUG
E—REAR BAND STOP CAP
F—TRANSMISSION

a. Clean the indicator pin plug (item B) and the surface of the transmission near the pin. Run the engine at idle speed with the transmission control lever in F1, HIGH-RANGE position.

b. Now unscrew the indicator pin plug (item B). The indicator pin should be flush or even with the machined surface of the transmission case. Use a straightedge to check the pin position. To adjust the band, loosen the front band adjusting screw locknut. If the indicator pin checks out too high, turn the adjusting screw in; if the indicator pin checks out too low, turn the adjusting screw out. When you are making the adjustment turn the adjusting screw until the indicator pin is EXACTLY FLUSH with the machined surface of the transmission case. Use a straightedge to check the adjustment. While holding the adjusting screw stationary, tighten the adjusting screw locknut to 40-50 lb-ft of torque. Recheck again with the straightedge to make sure that the indicator pin is exactly flush with the machined surface of the transmission case. Install the indicator pin plug in the transmission case and tighten the plug to 15-18 lb-ft of torque. This concludes the front band adjustment.

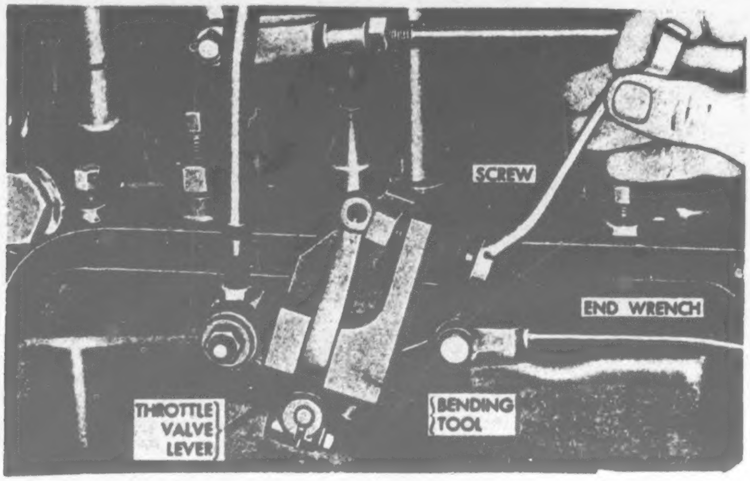


8. LINKAGE ADJUSTMENT. To make the throttle linkage adjustment, first disconnect the throttle valve control rod from the throttle valve lever by removing the cotter pin and clevis pin. Hold the transmission throttle valve lever gage against the machined surface of the flywheel housing rear half. Using the clevis pin that was just removed, check for free pin fit in the closed position of the throttle valve lever (item c).



A—FRONT BAND ADJUSTING SCREW
B—GAGING FIXTURE
C—THROTTLE VALVE LEVER
D—TRANSMISSION SHIFT LEVER
E—GAGING SURFACE

a. If the clevis pin cannot be freely inserted through the hole in the throttle valve lever and the hole in the gage, bend the throttle valve lever with the bending tool. Place the bending tool on the side of the lever, depending on the direction of the bend required. Turn the screw in the tool with a wrench to bend the lever.



b. After a correct adjustment is made, connect the throttle valve control rod to the throttle valve lever with the clevis pin and cotter pin. Next, disconnect the throttle valve control rod adjustable clevis from the idler shaft outer lever by removing the cotter pin and clevis pin. While holding the throttle valve lever against the stop, loosen the adjustable yoke locknut on the throttle valve control rod and adjust the yoke on the rod as necessary to obtain a free fit of the clevis pin through the yoke and idler lever.

c. After a free pin adjustment is made, shorten the throttle valve control rod by one or two turns of the adjustable yoke, then secure the clevis pin with the cotter pin and tighten the locknut against the adjustable yoke.

SECTION III. CONCLUSION

9. SUMMARY. In this lesson we have covered the construction, operation, and maintenance of hydramatic transmissions. As a wheeled vehicle mechanic you may be required to inspect, service, test, and make the required adjustments on these transmissions.

10. PRACTICE TASKS. Appendix B of this lesson contains a list of tasks associated with automatic transmissions. They are representative of the tasks you will be required to perform as a wheeled vehicle mechanic. Perform all of the tasks listed. Be sure you are under the supervision of an officer, NCO, or specialist qualified in the MOS when you practice the tasks. If you find you are having difficulty in certain tasks, restudy the appropriate training material and practice the tasks until you become proficient in each one.

EXERCISE

Note. - Review the lesson exercise instructions in lesson 1.

76. In what position should the hydramatic transmission control lever be when adding oil to the transmission with the engine running?

    a. Reverse
    b. F1 high range
    c. Neutral

77. What will indicate that oil is leaking between the front oil pump cover and the transmission case?

    a. Foam on the transmission side cover
    b. Drops on the oilpan capscrews
    c. Streaks along the torus cover

78. What is the MOST probable cause indicated if high oil level is noticed at frequent checking periods?

    a. Internal water leaks from the cooler case
    b. Oil is foaming too much
    c. Oil is leaking from the engine into the transmission

79. What is used with an oil pressure gage when making an oil pressure test?

    a. Oil temperature unit
    b. Tachometer
    c. Throttle valve lever gage

80. What is indicated if engine speeds are above 1,750 RPM during the stall test?

    a. The transmission is slipping
    b. The engine should be tuned
    c. The pressure takeoff plug is loose

81. What test is performed on the hydramatic transmission while the vehicle is traveling forward at 30 MPH in neutral with the ignition switch off?

    a. Front oil pump pressure
    b. Fluid coupling pressure
    c. Reduction unit oil pump pressure

82. What is the main difference between the front and rear bands in the 303M hydramatic transmission?

    a. The rear band is wrapped twice around the drum
    b. The rear band is longer than the front
    c. The front band is wrapped twice around the drum

83. Where are the two cone clutches located in the 303M hydramatic transmission?

    a. Reverse unit and reduction unit
    b. Reduction unit and direct drive assembly
    c. Accumulator assembly and behind the blocker

84. Which oil pump is connected to the torus cover through the front unit's planetary gear and is driven at engine speed?

    a. Rear pump
    b. Front pump
    c. Reduction pump

85. What is used to cause forced downshifts for increased acceleration?

    a. Throttle valve
    b. Compensator valve
    c. Transition valve

86. What drives the governor on the hydramatic transmission?

    a. Front pump input shaft
    b. Reduction pump drive shaft
    c. Transmission output shaft

87. How does the rear oil pump differ from the other pumps in the hydramatic transmission?

    a. It is located outside of the transmission
    b. It can operate in either forward or reverse speeds
    c. It is a much larger pump than the others

88. What might happen if the transmission is overfilled with oil?

    a. Fluid coupling will overfill
    b. Vehicle will not move forward
    c. Transmission will shift too fast or too slow

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89. What is one component of the hydramatic transmission that may be bent by the use of a special bending tool when making linkage adjustments?

    a. Throttle valve control rod
    b. Throttle valve lever
    c. Transmission shift lever yoke

90. What is used in the hydramatic transmission to lock two planetary members together?

    a. Multiple disk clutch
    b. Double wrapped band
    c. Reduction unit piston

91. What is the first thing to be done before any test of the transmission is performed?

    a. Check for proper oil level
    b. Warm transmission to operating temperature
    c. Place transmission in F1 low and set brakes

92. What should be done to the front band if the indicator pin is too much above the machined surface of the transmission?

    a. Turn in the adjusting screw
    b. Replace the band
    c. Grind off the pin

93. What range position should provide the highest oil pressure reading?

    a. Neutral
    b. F1
    c. Reverse

94. What is applied in the reverse unit when the transmission is in reverse?

    a. Band
    b. Cone clutch
    c. Multiple disk clutch

95. Which oil pump permits the vehicle to be started by towing?

    a. Reduction
    b. Front
    c. Rear

APPENDIX A

REFERENCES

TM 9-8000	Principles of Automotive Vehicles	Jan 56
TM 9-8024, w/C3, 5-7	Organizational Maintenance of GMC Series, 2-1/2-Ton, 6x6, Trucks	Oct 55

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APPENDIX B

PRACTICE TASK LIST

Practice Objective. . . . . After practicing the following tasks you will be able to:

1. Inspect the hydramatic transmission.
2. Make a stall speed test.
3. Make oil pressure tests on a hydramatic transmission.
4. Check and adjust the transmission and throttle linkage.

Note. - To perform the tasks listed below you will need a vehicle equipped with a hydramatic transmission, the -20TM for the vehicle, general mechanics toolbox, pressure gage, linkage gage, bending tool, and tachometer.

1. Inspect the transmission. Look for the following:
    a. Oil leaks.
    b. Water leaks.
    c. Proper oil level.
    d. Proper throttle linkage adjustment.
    e. Working range selector linkage.
2. Perform a stall speed test.
3. Perform an oil pressure check with the vehicle standing and in motion.
    a. Make the pressure check in all ranges.
    b. Notice pressure changes during shifting.
    c. Check for unusual noises during shifting.
4. Check and adjust the throttle linkage.

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ENLISTED MOS

CORRESPONDENCE/OJT COURSE

ORDNANCE SUBCOURSE 63B205

LESSON 6
TRANSFER CASES

OCTOBER 1975

DEPARTMENT OF ARMY WIDE TRAINING SUPPORT
US ARMY ORDNANCE CENTER AND SCHOOL
ABERDEEN PROVING GROUND, MARYLAND

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US ARMY ORDNANCE CENTER AND SCHOOL
CORRESPONDENCE/OJT COURSE

LESSON ASSIGNMENT SHEET

Ordnance Subcourse No 63B205 . . . . Wheeled Vehicle Clutches, Transmissions, and Transfers.

Lesson 6 . . . . Transfer Cases

Credit Hours . . . . Three

Lesson Objective . . . . After studying this lesson you will be able to:

1. Describe the construction of a transfer case.
2. Explain the operation of a transfer case.
3. Explain the operation of a sprag unit.
4. Explain how the transfer case assembly is lubricated.

5. Describe the procedure for inspecting transfer cases.

6. Describe the procedures for adjusting transfer linkage.

7. Describe procedures for replacing parts of a transfer case.

8. Describe the procedures for replacing a transfer case.

Text	Study Text
Materials Required	Answer sheet and response list
Suggestions	Refer to the illustrations while reading the text.

STUDY TEXT

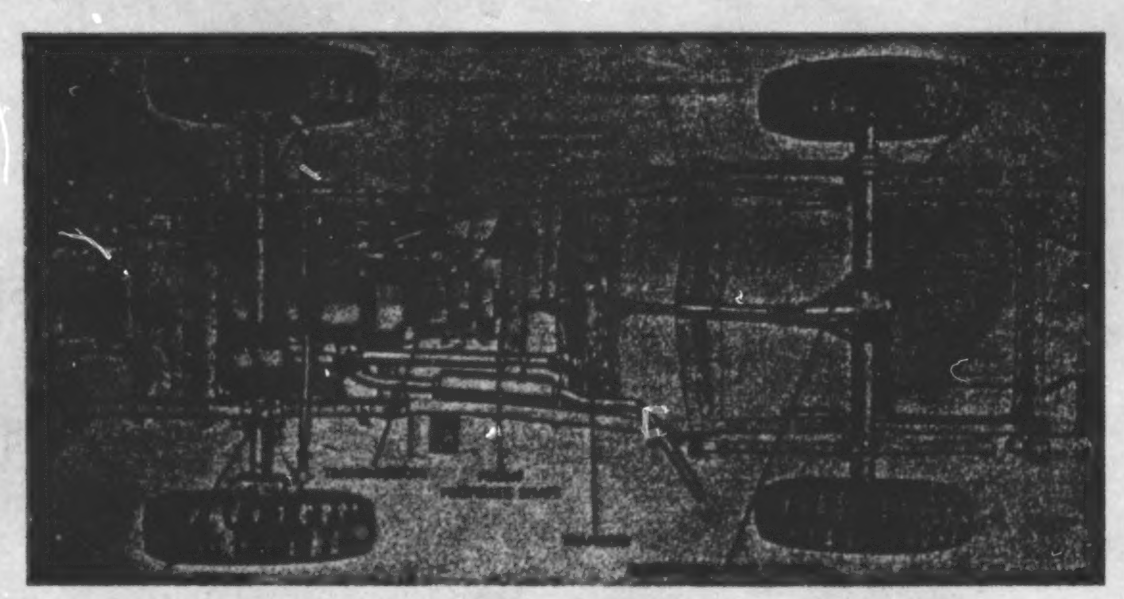
FOREWORD

On most wheeled vehicles the transmission, regardless if a conventional or automatic is used, provides power to one transmission output shaft which is positioned so it can drive the rear wheels only. When both the front and the rear wheels are used for propelling the vehicle, two outputs must be provided, one to transfer the power toward the front of the vehicle the other to the rear. A gearbox called the transfer case is normally used to receive the transmission output and distribute the power to the front and rear on all wheeled drive vehicles, such as the tactical vehicles of the Army. Transfer cases operate on the same basic principles as gearboxes that you have already studied. There is enough difference, however, between transfer cases and other gearboxes that a separate study of transfer cases is required in order for you to gain the knowledge needed to maintain them properly.

SECTION I. CONSTRUCTION AND OPERATION OF TRANSFER CASES

1. INTRODUCTION. In the previous lessons we discussed how transmissions could provide various gear ratios so that the engine could develop enough power for starting a vehicle, running at high speeds, and pulling heavy loads. We also mentioned that military vehicles had to be able to operate in mud, snow, sand, and other unusual terrains. To do this, driving power has to be available at the front wheels as well as the rear wheels so that vehicle won't get stuck. Therefore, tactical military wheeled vehicles include a second gearbox called the transfer case. Its purpose is to take the output power from the transmission and divide it so that it will drive the rear wheels at all times and drive the front wheels when needed.

a. The transfer case can be mounted in several ways in a vehicle. It can be a separate component mounted to the rear of the transmission and driven by a propeller shaft connecting it to the output of the transmission. It can also be a part of the transmission and driven by a gear on the output shaft of the transmission. No matter how the transfer is designed, its intent is to satisfy one or more of the following needs:



(1) To transfer the transmission power to a point low enough so that a propeller shaft can be mounted under the engine and power the front axle.

(2) To provide an output to power one or more rear axles.

(3) To provide a high and low gear ratio for vehicles that do not have the necessary gear reductions in the transmission.

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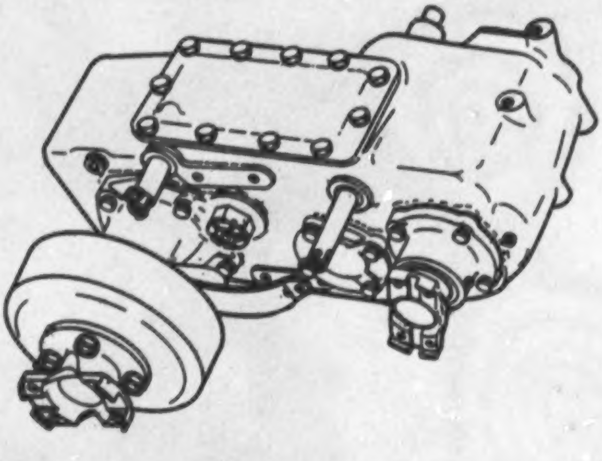
(4) To provide arrangements for engaging and disengaging front wheel drive and high and low ranges when applicable.

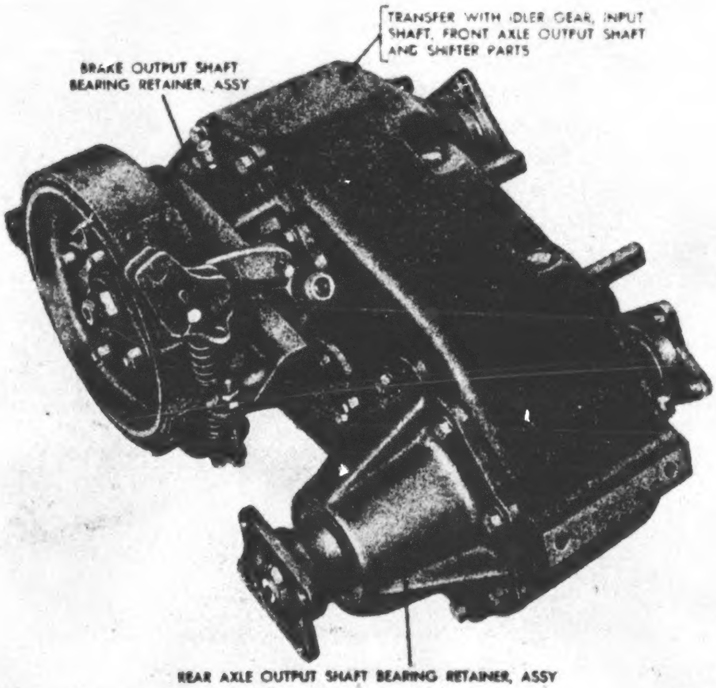
b. From the purpose of a transfer case as listed in the above paragraph, you can see that the shape, mounting, construction, and appearance of transfers for various vehicles will differ. In the paragraphs below we will discuss the wheeled vehicle transfer cases you will work with.

(1) The transfer case used with the M151A1, 1/4-ton vehicle is also mounted directly on the transmission. This transfer does not provide a separate gear reduction and has only a direct drive. It does have a shift lever for engaging and disengaging the front wheel drive.

(2) The transfer case of the M561, 1-1/4-ton truck is mounted at the output end of the transmission. It transfers power from the transmission to the propeller shafts and differentials. Selections are high and low operating ranges, neutral to disengage the case, and two- or six-wheel drives. Two-wheel drive disengages the front and rear axles leaving the center wheels only to drive the vehicle.



(3) The 3/4-ton and 1-1/4-ton trucks use the same type of transfers. They are mounted behind the transmission and connected to the output of the transmission by a small propeller shaft. They contain a high and low range. Engaging and disengaging of front wheel drive and range selections are done manually with shift levers.


TRANSFER WITH IDLER GEAR, INPUT SHAFT, FRONT AXLE OUTPUT SHAFT AND SHIFTER PARTS
BRAKE OUTPUT SHAFT BEARING RETAINER, ASSY
REAR AXLE OUTPUT SHAFT BEARING RETAINER, ASSY

(4) The 2-1/2-ton and 5-ton truck transfers are similar. They are mounted behind the transmission and powered by a propeller shaft. All have a high and low range which is selected with a manual lever. On some vehicles the front wheel drive engages automatically anytime the rear wheels start turning faster than the front wheels. This is done with a sprag unit that is similar to a bicycle coaster brake. On other models the front wheel drive is engaged and disengaged with a manual shift.

c. For our discussion in this lesson we will refer to the transfer cases used on 2-1/2-ton trucks primarily. Most transfers work about the same. However, more organizational maintenance is required on 2-1/2-ton transfers than most other models.

2. CONSTRUCTION OF A TYPICAL TRANSFER. To understand how a transfer case works it is best to first become familiar with the location of the internal parts.

Note. - The foldout in the back of this pamphlet identifies each of the components by letter.

a. The typical transfer assembly has one input shaft and three output shafts. Other transfers may have one input shaft and two output shafts: one shaft for the front axle and one for the rear axle or axles. Their operations will be much the same.

b. We will discuss the components as they are listed alphabetically.

(1) At the top of the picture we notice gear (A). It is mounted on the main input shaft (C) but is free to rotate without turning the shaft. It has external teeth on the outside that are in constant mesh with gear (P). It also has internal gear teeth on the inside. Gear (B) is also mounted on the main input shaft (C). However, notice that this gear is splined to the shaft and must turn anytime the input power shaft turns. It can slide back and forth on the shaft between gears (A) and (D). This gear has external teeth and acts as a dog clutch between gear (A) and shaft (C).

(2) Gear (D), the rear axle (rear unit) drive gear, is fastened to and turns item (E), the rear axle (rear unit) drive shaft assembly. Gear (D) is in mesh with gear (F), the idler shaft constant mesh gear.

(3) Gear (F) has both external and internal teeth. It is mounted on, and is free to turn on, item (G), the idler shaft. The idler shaft constant mesh gear is in mesh with gear (H), the drive shaft constant mesh gear.

(4) The drive shaft constant mesh gear has external and internal teeth. It is mounted on item (J), the rear axle (front unit) drive shaft. An external tooth gear, fastened to item (J), is in mesh with the internal teeth of the drive shaft constant mesh gear (H). This gear turns item (J), the rear axle (front unit) drive shaft.

(5) Gear (H) is in mesh with gear (K), the drive shaft constant mesh gear. This gear has external and internal teeth and is mounted on, and free to turn on, item (L), the front axle drive shaft.

(6) Gear (M), the drive shaft sliding gear, has external teeth and internal splines and can slide on the splines of the front axle drive shaft. When the external teeth of gear (M) are in mesh with the internal teeth of the drive shaft constant mesh gear (K), the front axle drive shaft is engaged and will turn at the same speed as gear (K).

(7) Gear (N), the idler shaft low-speed gear, is mounted on the idler shaft. One end of gear (N) is in mesh or engaged with gear (F), the idler shaft constant mesh gear. The other end is in mesh or engaged with item (P), another idler shaft constant mesh gear. This locks gears (F), (N), and (P) together so they turn as a unit. The idler shaft constant mesh gear (P) is in mesh with the main shaft constant mesh gear (A).

3. **OPERATION.** Now that you have seen how the parts of a transfer fit together, we will take a look at what goes on when the transfer is in operation. When the transfer is operating in high range, with the front wheel drive engaged, all wheels are pulling.

a. Power comes into the transfer from the transmission on the main shaft (C). When the main shaft turns, the main shaft sliding gear (B) turns because it is splined to the main shaft. In high range the main shaft sliding gear is in mesh with the internal teeth of gear (A), the main shaft constant mesh gear. This causes gear (A) to turn.

(1) The external teeth of gear (A) are in mesh with the external teeth of gear (P), the idler shaft constant mesh gear. When gear (A) turns it drives gear (P).

(2) One end of gear (N), the idler shaft low-speed gear, is in mesh with gear (P). The other end is in mesh with gear (F), the other idler shaft constant mesh gear. This means that when gear (P) turns, all gears on the idler shaft turn.

(3) Gear (F) is in mesh with gear (D). When gear (F) turns it drives gear (D), gear (D) turns shaft (E) which sends power to the rear axle rear unit.

(4) Gear (F) is also in mesh with and drives gear (H). The internal teeth of gear (H) are in mesh with the gear fastened to shaft (J). When gear (H) is turned power is sent to the rear axle front unit.

(5) Gear (H) is also in mesh with and turns gear (K). When the front wheel drive is engaged, gear (K) is in mesh with and drives gear (M), the drive shaft sliding gear. Gear (M) is splined to shaft (L), the front axle drive shaft. When gear (M) is turned power is sent through shaft (L) to the front axle. The driver by means of a shift lever and linkage can slide gear (M) away from gear (K). When gear (M) is not in mesh with gear (K), no power is being sent to the front axle.

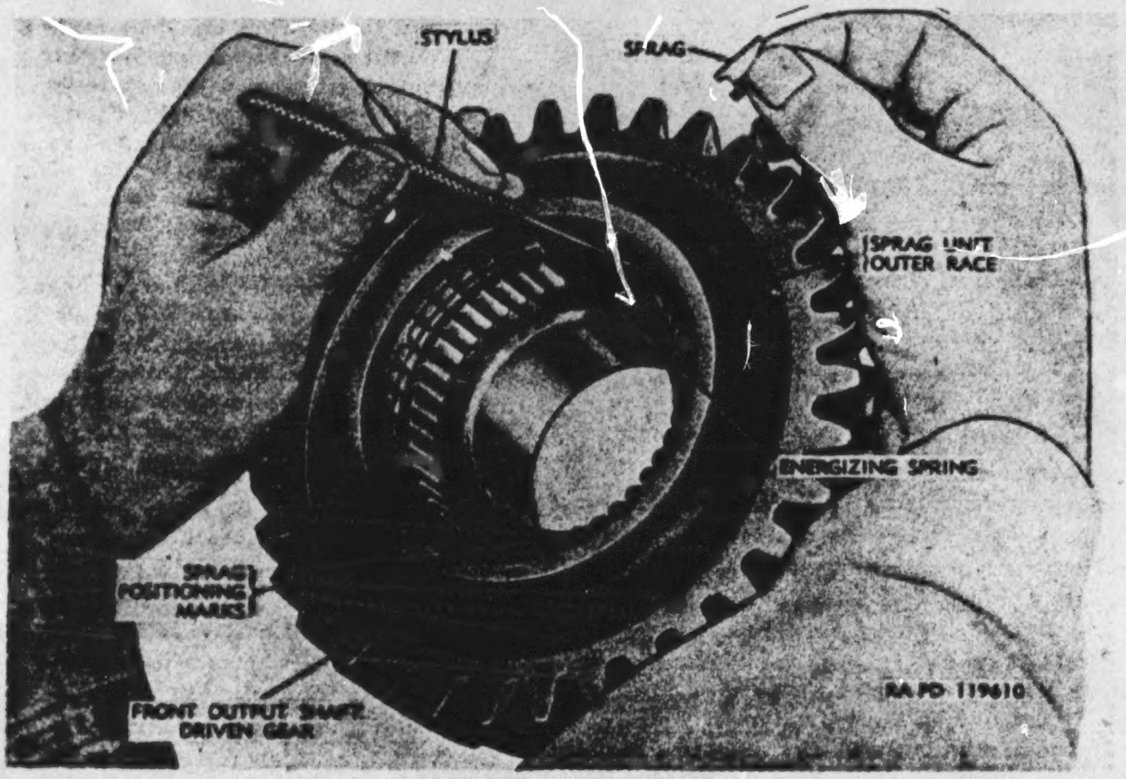
(6) When more torque is needed to move the vehicle the driver can shift the transfer to low range. The shifting linkage on some vehicles is made so that the vehicle must be in front wheel drive before shifting to low range. This prevents the driver from sending full torque to the rear wheels only, which might cause damage.

(7) When the transfer is shifted to low range, the mainshaft sliding gear (B) is disengaged from the constant mesh gear (A). It is then engaged with the idler shaft low-speed gear (N). Gear (B) is the driving gear and is smaller than driven gear (N). This gives less speed and more torque or a gear reduction. From here on the power flow is the same as in high range. The transfer is in neutral while gear B is not in mesh with either gear A or gear N.

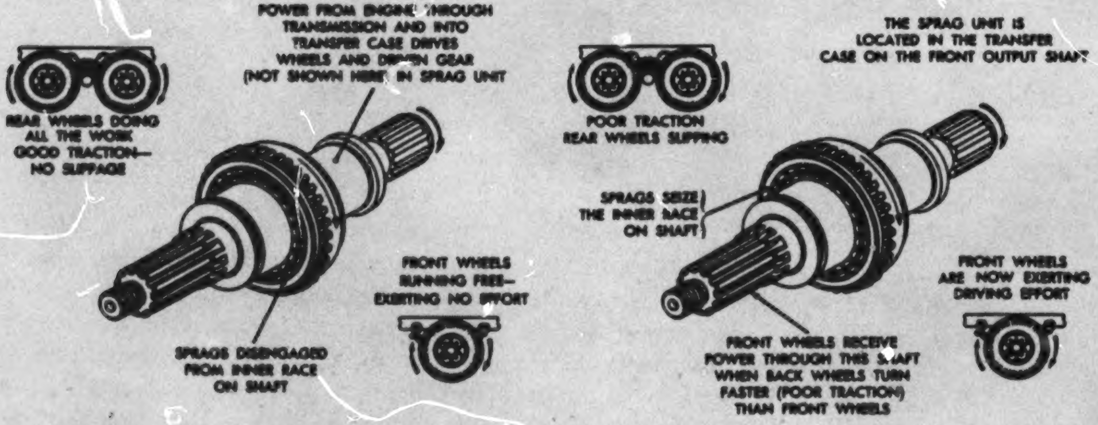
b. Some transfers contain an overrunning sprag unit (or units) on the front output shaft. The operation of these units is much like that of an overrunning clutch in the starting motor.

(1) On these units the transfer is made to drive the front axle a little slower than the rear axle(s). During normal operation on good roads, when both front and rear wheels turn at the same speed, only the rear wheels drive the vehicle. However, if the rear wheels start to slip, they turn faster than the front wheels. If this happens, the sprag unit automatically engages so that the front wheels also drive the vehicle. The sprag unit simply provides an automatic means of engaging the front wheel drive whenever the back wheels start to slip. There are three types of sprag units used with transfers. They are a single-sprag unit, a double-sprag unit, and an air-operated double-sprag unit. They all work in almost the same way. This type transfer is much like the one we just discussed. The main difference is that a sprag unit is used instead of the hand-operated sliding gear or clutch on the front output shaft.

(2) The sprag is a steel block shaped to act as a wedge in the complete assembly. In some units there are 42 sprags assembled into an outer race and held in place by two springs. The springs fit into the notches in the ends of the sprags and hold them in place. The outer race is in the driven gear on the front output shaft. The inner race is on the front output shaft.



(3) Now let's see how a single sprag unit operates. During normal operation the front and rear wheels are turning at the same speed. The outer race of the sprag unit (in the driven gear) turns a little slower than the inner race (on the front output shaft). This prevents the sprags from wedging between the races. No lockup takes place and the front wheels turn freely; they are not driven. However, if the rear wheels start to slip and turn faster than the front wheels, the outer race tries to turn faster than the inner race. When this happens the sprags wedge or jam between the two races. The two races now turn as a unit and provide driving power to the front wheels. As soon as the rear wheels quit slipping and start to turn the same speed as the front wheels, the sprags release.


POWER FROM ENGINE THROUGH TRANSMISSION AND INTO TRANSFER CASE DRIVES WHEELS AND DRIVEN GEAR (NOT SHOWN HERE) IN SPRAG UNIT
REAR WHEELS DOING ALL THE WORK GOOD TRACTION— NO SLIPPAGE
FRONT WHEELS RUNNING FREE— EXERTING NO EFFORT
SPRAGS DISENGAGED FROM INNER RACE ON SHAFT
THE SPRAG UNIT IS LOCATED IN THE TRANSFER CASE ON THE FRONT OUTPUT SHAFT
POOR TRACTION REAR WHEELS SLIPPING
SPRAGS SEIZE THE INNER RACE ON SHAFT
FRONT WHEELS ARE NOW EXERTING DRIVING EFFORT
FRONT WHEELS RECEIVE POWER THROUGH THIS SHAFT WHEN BACK WHEELS TURN FASTER (POOR TRACTION) THAN FRONT WHEELS

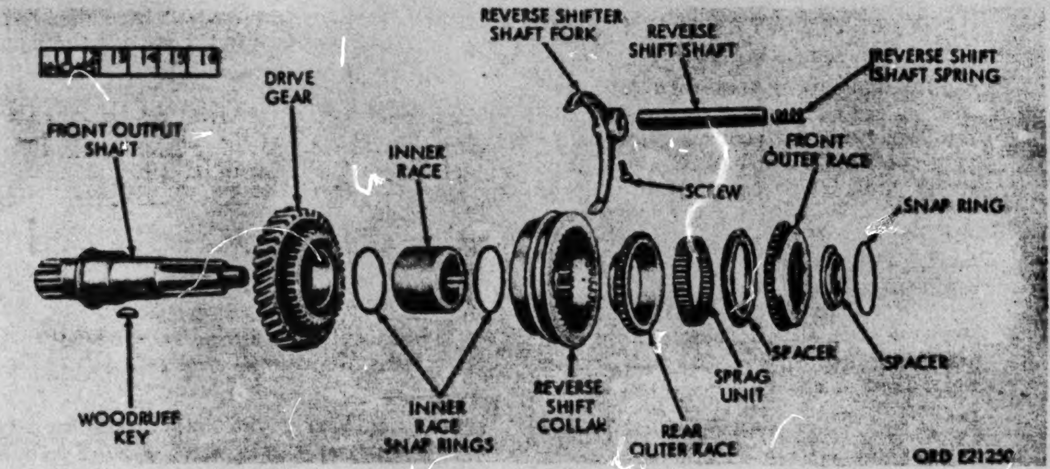
1. FRONT WHEELS RUNNING FREE

2. FRONT WHEELS DRIVING

Principle of sprag-unit action.

(4) In reverse it is necessary to lock out the single sprag unit. The turning is reversed; this means that we cannot drive through the sprag unit. The lockout is done through a linkage to the transmission that shifts a reverse shift collar in the transfer. As the reverse shift collar is shifted, internal splines in the collar mesh with external splines on the reverse shift driven gear and on the front output gear so there is a solid drive around the sprag unit.

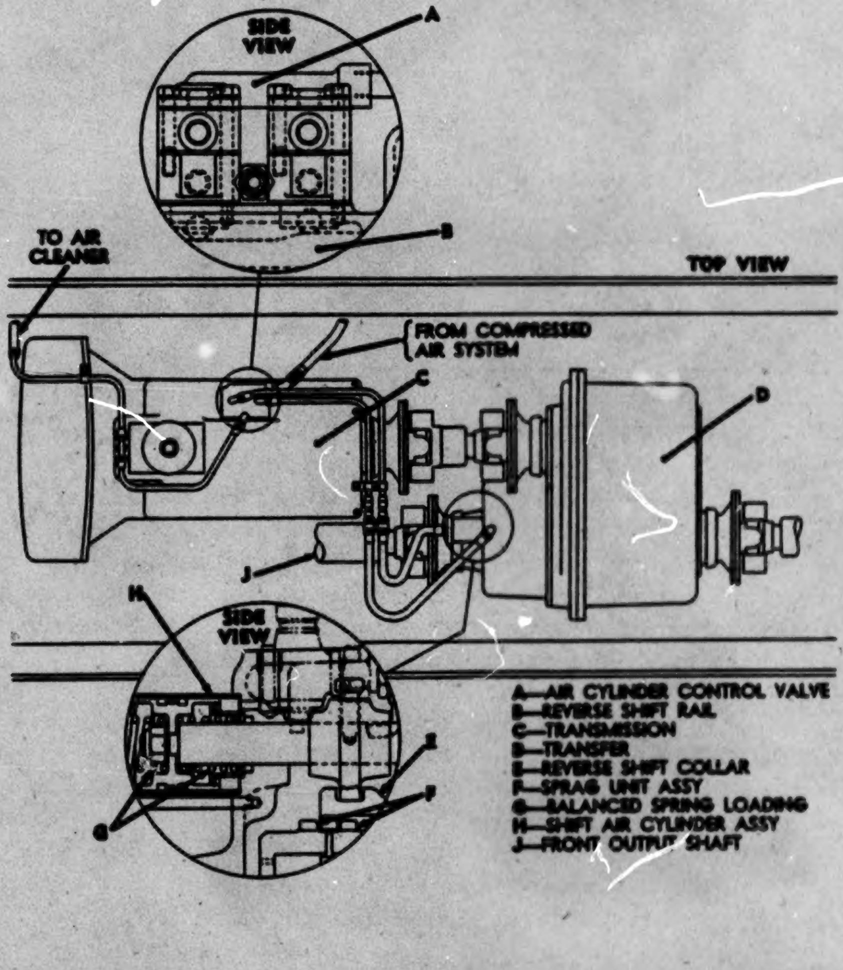
(5) The double-sprag unit operates the same way as the single-sprag in forward speeds. The difference between the two units shows up in reverse. In the double-sprag unit, a second sprag unit has been added which operates only in reverse.



(6) When the shift is made to reverse, the forward sprag unit is locked out, almost exactly the same as the single-sprag unit. However, the reverse-sprag unit now comes into operation. The front wheels drive, in reverse, when the rear wheels start to slip. The shift from one sprag unit to the other is done by a linkage to the transmission. This shifts a reverse shift collar in the transfer. As the reverse shift collar is shifted, internal splines (or teeth) in the collar unmesh from the external splines on the outer race of one sprag unit. It then meshes with the external splines on the other sprag unit.

(7) Another type sprag unit is the air-controlled double-sprag unit. This unit does the same job as the double-sprag unit we just discussed. The main difference is an air valve on the transmission low and reverse shift shaft. This valve automatically shifts the sprag unit to forward or reverse whenever the transmission is shifted to low or reverse.

(8) This illustration shows an air-control diagram of the transmission and transfer assembly using an air-controlled double-sprag unit. This type is used in the 5-ton truck. Now let's take a look at what happens when there is compressed air in the system, and the transmission is in a forward or neutral position. The air cylinder control valve (item A) will admit air under pressure from the compressed air system into the shift air cylinder assembly (item H). The air is then admitted to the forward-shift side of the spring-balanced piston in the cylinder. This moves the piston and causes engagement of the forward sprag unit. When the transmission is shifted into reverse, the air cylinder control valve (item A) admits air to the opposite side of the piston. This causes engagement of the reverse sprag unit. When the forward sprag unit is engaged, the front wheels will freewheel or turn only in a forward direction. If the reverse sprag unit is engaged, the front wheels cannot be turned in a forward direction. A parked vehicle, with air pressure in the system and the transmission in neutral, cannot be pushed backward until the transmission is shifted to reverse.



A—AIR CYLINDER CONTROL VALVE
B—REVERSE SHIFT RAIL
C—TRANSMISSION
D—TRANSFER
E—REVERSE SHIFT COLLAR
F—SPRAG UNIT ASSY
G—BALANCED SPRING LOADING
H—SHIFT AIR CYLINDER ASSY
J—FRONT OUTPUT SHAFT

c. The transfer uses the dip or splash type of lubrication system. The gears are in the transfer case and the case is filled with gear oil (GO 90 in warm weather). As the gears operate, they turn in the oil and no pressure is used. The turning gears will throw the oil onto the shafts and into the bearings. The oil is kept from leaking from the case by seals around the input and output shafts.

SECTION II. MAINTENANCE OF TRANSFER CASES

4. INSPECTION AND ADJUSTMENT. The upkeep that will be done by the organizational maintenance will be mainly maintaining lube levels, linkage adjustment, cleaning, and tightening. Before any of these things are done, the transfer case should be inspected to see just what is needed.

a. The following is a checklist to be used as a guide when inspecting the transfer:

(1) Check the oil level and inspect for oil leaks.

(2) Inspect for loose or missing bolts.

(3) Check the linkage for completeness and operation.

(4) Inspect for oil or grease leaks and plugged air vents.

(5) Inspect for damage to the transfer case.

(6) Operate the transfer and check the shift.

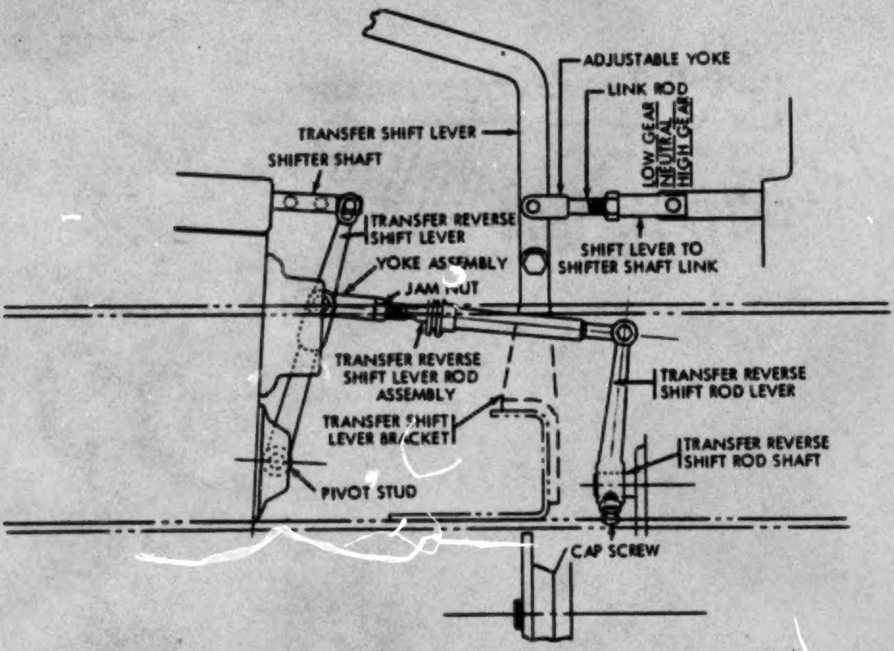
(7) Check for unusual noises during operation.

b. On the M35A2, 2-1/2-ton truck, check the sprag unit for proper operation. To test the sprag operation, run the vehicle and bring the transfer to operating temperature, then make the following tests: raise one front wheel off the ground, shift the transmission into reverse, and turn the front wheel backward. Next, try to turn it forward. The wheel should be free to turn backward, but not forward.

(1) Shift the transmission into low gear and turn the front wheel forward. Then try to turn the wheel backward. The wheel should be free to turn forward but not backward. If these conditions do not exist, the reverse linkage must be adjusted.

(2) Shift the transmission to neutral. During this shift watch to see if the shift rod lever moves.

(3) If the lever moves, the transfer reverse shift lever rod assembly must be shortened. Shorten the rod by loosening the jam nut and turning the rod into the yoke. If the lever does not move, the rod may be adjusted properly. However, it is more likely that the transfer reverse shift lever rod assembly must be lengthened.

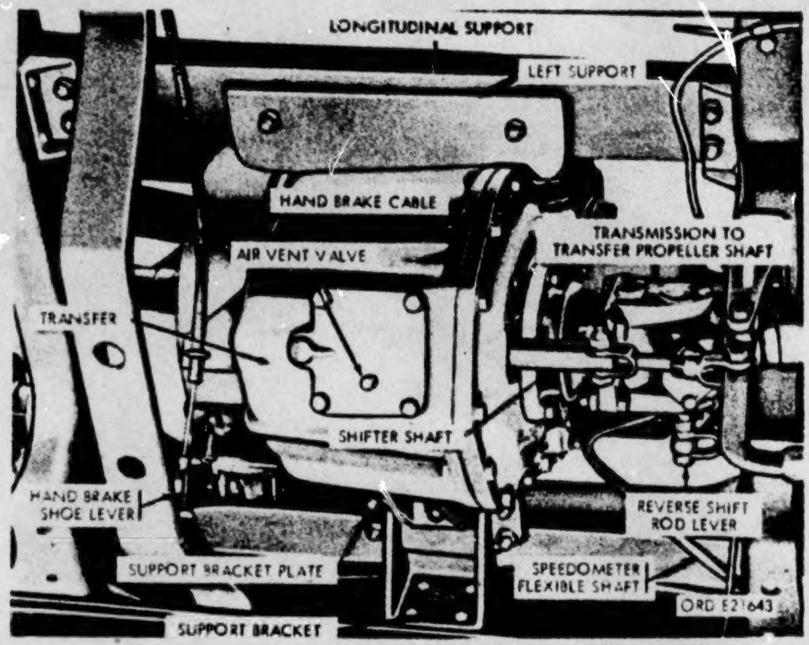

ADJUSTABLE YOKE
LINK ROD
LOW GEAR
NEUTRAL
HIGH GEAR
TRANSFER SHIFT LEVER
SHIFTER SHAFT
TRANSFER REVERSE SHIFT LEVER
YOKE ASSEMBLY
JAM NUT
SHIFT LEVER TO SHIFTER SHAFT LINK
TRANSFER REVERSE SHIFT LEVER ROD ASSEMBLY
TRANSFER REVERSE SHIFT ROD LEVER
TRANSFER SHIFT LEVER BRACKET
TRANSFER REVERSE SHIFT ROD SHAFT
PIVOT STUD
CAP SCREW

(4) Lengthen the rod by loosening the jam nut, and screwing the rod out of the yoke. Repeat the above test procedures until the lever does not move. It should be just on the verge of moving when the transmission is shifted from first gear to neutral.

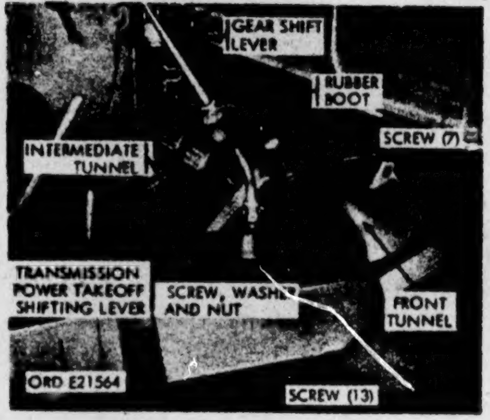
(5) Recheck the adjustment with the transmission in neutral by trying to pry the reverse shift rod lever away from the transfer case with a screwdriver. If the lever cannot be moved, the forward speed adjustment is completed. If the lever moves, shorten the reverse shift lever rod assembly as described above.

(6) Shift the transmission into reverse and turn the jacked up wheel one-half turn backward, making sure the transmission stays in reverse. Try to pry the shift rod lever toward the transfer. If the lever can be moved one-sixteenth of an inch or less, the reverse speed adjustment is complete. If the lever moves more than one-sixteenth of an inch, lengthen the shift lever rod assembly and recheck the forward and reverse speed adjustment. Rechec the sprag unit operation.

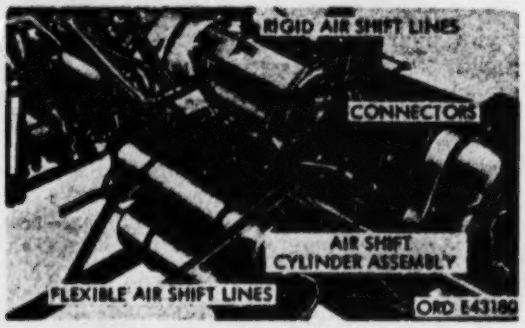
5. **PARTS REPLACEMENT.** Some parts of the transfer case can be replaced at the organizational maintenance level. To replace the transfer case air vent valve, remove the old valve by turning it to the left (counterclockwise) until it is backed out of the transfer output cover. Install the new valve by turning it clockwise until it is seated properly on the transfer output cover.



a. To replace the transfer cover output seal (gasket) use the following procedures: remove the gearshift lever and boot, remove the screws and the intermediate and rear tunnels from the cab, remove the screws and lockwashers, and remove the transfer output cover and seal. To reassemble install a new seal, install the output cover and secure it with screws and lockwashers, install the intermediate and rear tunnels and secure them with screws, and replace the gearshift lever and boot.



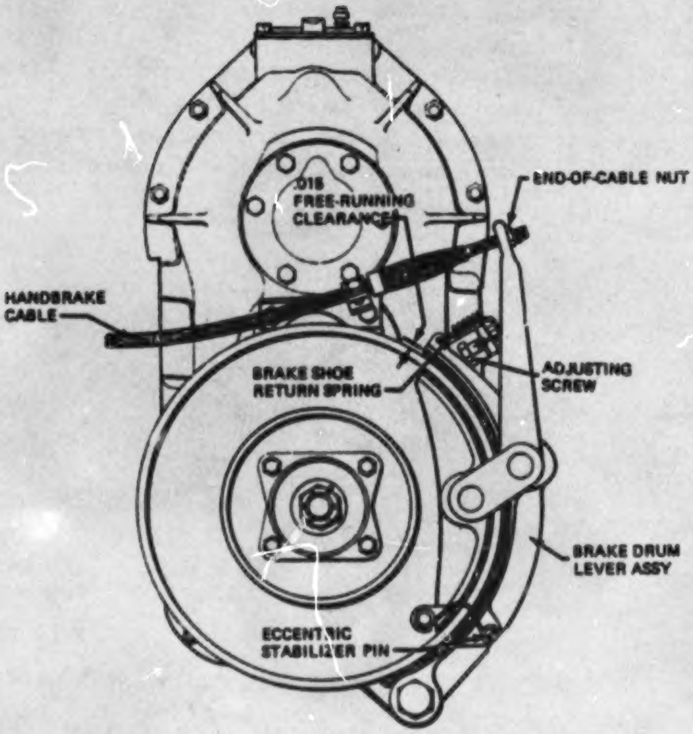
b. To replace the flexible air shift line on a 5-ton truck use the following procedures: from beneath the vehicle, unscrew the air shift line connectors at the junction of the rigid and flexible air shift lines and disconnect the lines. Tag the lines so there will be less chance of getting them crossed. Should the lines be crossed, it will cause power train windup and damage may occur. Connect the new lines to the transfer and the rigid air shift lines.



6. REPLACEMENT. Normally, transfer cases are not replaced at the organizational maintenance level. However, when authorized by support maintenance, a using unit can do this type of work if they have the necessary tools available and the trained people on hand to do it. Support maintenance will also send contact teams to using units to do this type of job. When they do, the unit mechanics will often be asked to assist the contact teams. Because of these possibilities, the organizational maintenance mechanic should know the general procedures for removing and installing transfer cases.

a. The following procedures are used to remove the transfer from the 2-1/2-ton truck. As a word of caution, you must always jack up one wheel of an axle before attempting to remove the propeller shaft from that axle. The reason for this is that when turning a corner the front and rear wheels of a vehicle do not travel the same distance. As a result, a strain called "wind-up" builds up between the axles. As soon as one wheel is raised the strain unwinds.

(1) The first step in replacing a transfer is to remove the propeller shafts at the transfer flanges. This includes the transmission to transfer, transfer to front axle, and transfer to forward rear axle propeller shafts. To disconnect the shafts, remove the bolts and nuts that secure the universal flange to the transfer flange for each of the three shafts.



(2) Remove the nut that secures the handbrake cable to the handbrake shoe lever. Loosen the retaining nuts of the U-bolt that secures the cable to the transfer case and pull the cable through the U-bolt. Lay the fre end of the cable up on some portion of the vehicle frame so that it will be out of the way.

(3) To remove the high- and low-range shift lever linkage, remove the two bolts and nuts that secure the shifter shaft link to the shift lever and the transfer shifter shaft and remove the link. (Refer to the illustration with paragraph 4b(3).) Then remove the bolt and nut securing the shift lever to the shift lever bracket and remove the shift lever.

(4) To remove the reverse shift linkage, loosen the locking nut on the capscrew that secures the reverse shift rod lever on the transfer revers shift rod shaft. Remove the capscrew and slide the lever off the shaft.

(5) Disconnect the speedometer flexible shaft from the angle drive adapter on the transfer and remove the speedometer cable.

(6) Drain the lubricant from the transfer. Using a hydraulic jack or some other lifting device, support the transfer in the position in which it is held by the vehicle.

(7) Remove the four safety nuts and screws holding the transfer support bracket plate to the transfer support bracket on the right side of the transfer. Remove the four safety nuts and screws holding the transfer longitudinal support to the longitudinal support brackets at left of the transfer. Lower the transfer from its position and remove it from the vehicle. Remove the two bolts holding the right support to the transfer case. Remove the support and support bracket plate as a unit. Remove four bolts holding the left support to the transfer case. Remove the left support and longitudinal support as a unit. Remove the transfer air vent valve from the transfer.

b. To install the transfer, use the following procedures. Install the air vent valve. Install the left support and longitudinal support to the transfer case with four self-locking hex-head bolts. Install the right support and support bracket plate to the transfer case with two self-locking hex-head bolts. Raise the transfer into position and secure the support bracket plate to the support bracket with four hex-head screws and safety nuts. Secure the longitudinal support to the support brackets with four hex-head screws and safety nuts.

(1) Install the angle drive adapter on the transfer. Connect the speedometer flexible shaft to the adapter. Install the transfer shift lever and reverse shift rod lever on the transfer and make sure the offset end of the lever is toward the transfer.

(2) Connect the handbrake cable to the handbrake lever, using the securing nut, and to the transfer case bracket with the cable to bracket U-bolt.

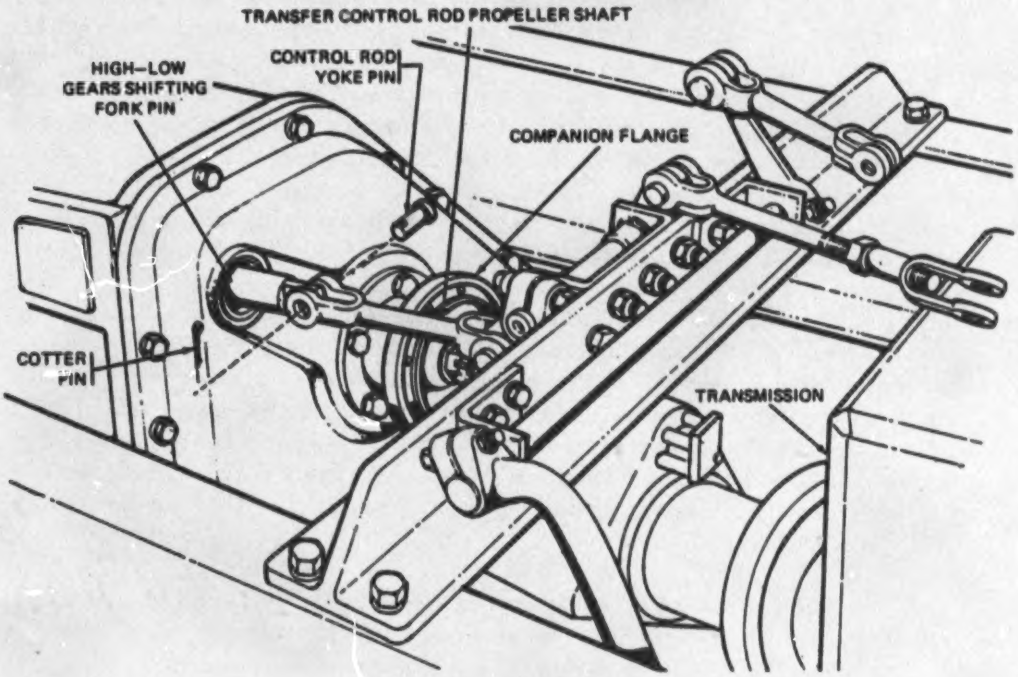
(3) Connect the front axle transmission and the forward rear axle propeller shafts to the transfer.

(4) Lubricate the transfer according to lubrication order, LO 9-2320-209-12.

(5) Check the transfer linkage adjustment. This must be done anytime the linkage is removed from the transfer or a new transfer is installed.

(6) Some 2-1/2-ton trucks have a power takeoff (PTO) mounted on or driven by the transfer case. The procedures for removing the transfer case will be the same, except that the PTO linkage and propeller shafts must also be removed.

c. The procedures for removing transfers of other vehicles is much the same. The accompanying illustration shows the disconnect points for removing the transfer from a 5-ton vehicle.



SECTION III. CONCLUSION

7. SUMMARY. In this lesson we have discussed the construction and operation of the transfer case used on wheeled vehicles, and the maintenance that you, as a wheeled vehicle repairman, may be required to perform. Although the transfer case is not a maintenance problem too often, you should know how to repair it when trouble occurs.

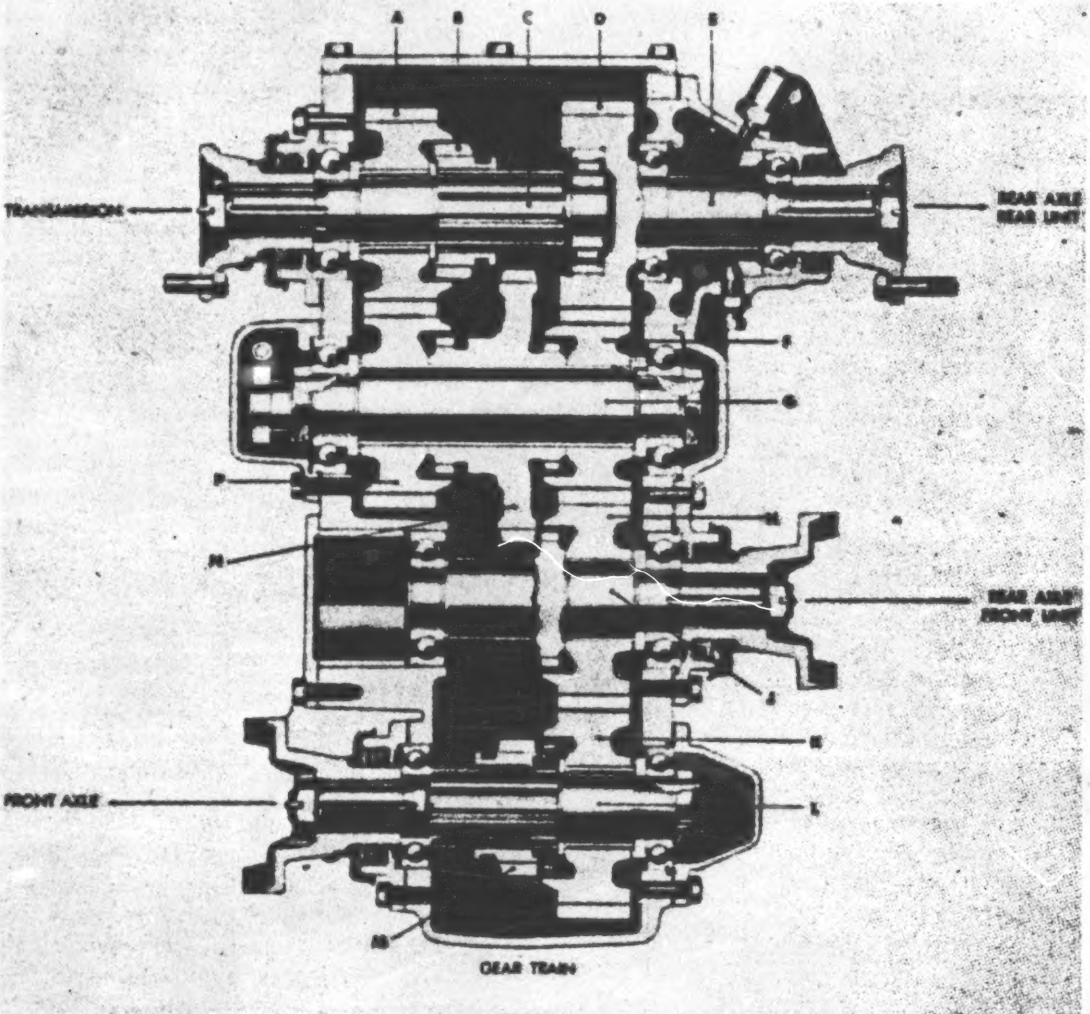
8. PRACTICE TASKS. Appendix B of this lesson contains a list of tasks associated with wheeled vehicle transfer case assemblies. They are representative of the tasks you will be required to perform as a wheeled vehicle mechanic. Perform all the tasks listed. Be sure you are under the supervision of an officer, NCO, or specialist qualified in the MOS when you practice the tasks. If you find you are having difficulty in certain tasks, restudy the appropriate training material and practice the tasks until you become proficient in each one.

EXERCISE

NOTE. - QUESTIONS 96 THROUGH 101 PERTAIN TO FIGURE 1.

96. What is driven by the main shaft constant mesh gear?

a. Main shaft sliding gear
b. Rear axle (rear unit) drive gear
c. Idler shaft constant mesh gear



A—MAINSHAFT CONSTANT MESH GEAR
B—MAINSHAFT SLIDING GEAR
C—MAINSHAFT
D—REAR AXLE (REAR UNIT) DRIVE GEAR
E—REAR AXLE (REAR UNIT) DRIVE GEAR ASSEMBLY
F—IDLER SHAFT CONSTANT MESH GEAR
G—IDLER SHAFT
H—DRIVE SHAFT CONSTANT MESH GEAR
J—REAR AXLE (FRONT UNIT) DRIVE SHAFT
K—DRIVE SHAFT CONSTANT MESH GEAR
L—FRONT AXLE DRIVE SHAFT
M—DRIVE SHAFT SLIDING GEAR
N—IDLER SHAFT LOW SPEED GEAR
P—IDLER SHAFT CONSTANT MESH GEAR

Figure 1

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97. In which drive range is the main shaft sliding gear engaged with item (N)?

a. Low
b. High
c. Neutral

98. What drives the main shaft sliding gear in the transfer?

a. Idler shaft low speed gear
b. Main shaft
c. Idler shaft

99. When the transfer is in neutral the

a. drive shaft sliding gear is disengaged from the drive shaft constant mesh gear.
b. main shaft sliding gear is disengaged from the main shaft constant mesh gear.
c. main shaft sliding gear is engaged with the idler shaft low speed gear.

100. Power flow to the rear axle unit, with the transfer in high range is from

a. A to P to N to F to D
b. C to B to A to P to N to F to D to E
c. B to P to G to F to D to E

101. What drives the mainshaft constant mesh gear?

a. Idler shaft constant mesh gear
b. Drive shaft sliding gear
c. Main shaft sliding gear

102. What type of sprag unit is used on the 5-ton truck?

a. Single sprag
b. Double sprag
c. Air controlled double sprag

103. In a double sprag, when does the added sprag unit operate?

a. In high range only
b. In forward gear only
c. In reverse gear only

104. The sprag unit in a transfer case engages when

a. the vehicle is in reverse.
b. the front wheels turn faster than the rear wheels.
c. the rear wheels turn faster than the front wheels.

105. The sprags used in a sprag unit are

a. steel blocks.
b. steel balls.
c. steel rollers.

106. A vehicle having an air operated double sprag unit, with air in the system, should not be pushed backward until the

a. transfer is shifted to high.
b. transmission is shifted to neutral.
c. transmission is shifted to reverse.

107. What type lubrication system is used in the transfer case?

a. Full force
b. Dip or splash
c. Force and splash

108. When testing sprag unit operation on the M35A2, 2-1/2-ton truck, with the transmission in low, the jacked up wheel should

a. be free to turn forward but not backward.
b. be free to turn backward but not forward.
c. be free to turn either way.

109. What must be done if the shift rod lever moves when shifting the transmission of an M35A2 2-1/2-ton truck, from low to neutral?

a. Lengthen the reverse shift lever rod
b. Shorten the reverse shift lever rod
c. Lengthen the shift lever to shifter shaft link

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110. If the reverse shift rod lever can be pryed away from the transfer case with a screwdriver when checking the linkage adjustment of a 2-1/2-ton truck transfer, the

a. reverse speed adjustment is complete.
b. reverse shift lever rod should be shortened.
c. reverse shift lever rod should be lengthened.

111. Which are normally replaced at the organizational maintenance level?

a. Transfer output cover seal and air vent valve
b. Transfer air vent valve and front output shaft seal
c. Air vent valve and sprag unit

112. What precaution should be taken before removing any propeller shaft from a 2-1/2-ton truck?

a. Remove the battery cable
b. Place the transmission in low
c. Jack up one of the wheels driven by the propeller shaft

113. Which item is removed and reused when replacing the transfer case on a 2-1/2-ton truck?

a. Air vent valve
b. Transfer cover output seal
c. Sprag unit

114. What would result if the air shift lines were crossed on the 5-ton truck?

a. Sprag unit would not shift to reverse
b. Power train would wind up
c. Transfer would stay in neutral

115. Which of the following is NOT a purpose of the transfer case?

a. Provide gear reduction
b. Provide reverse gear
c. Provide a means of driving the front wheels

APPENDIX A

REFERENCES

TM 9-2320-209-20, w/C1-6	Organizational Maintenance of the 2-1/2-Ton, 6x6, M34, M35, and M36 Series Trucks	Apr 65
TM 9-2320-211-20	Organizational Maintenance of the 5-Ton, 6x6, Tractor Trucks, Cargo Trucks, and Wreckers	Jun 73
TM 9-2320-218-20, w/C2	Organizational Maintenance of the 1/4-Ton, 4x4, M151 Series Trucks	Sep 71
TM 9-2320-242-20, w/C2	Organizational Maintenance of the 1-1/4-Ton, 6x6, M561, Truck, Cargo, and M792 Truck, Ambulance Vehicles	Aug 70
TM 9-2320-260-20	Organizational Maintenance of the 5-Ton, 6x6, M809 Series Trucks	Jul 72
TM 9-8000	Principles of Automotive Vehicles	Jan 56

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APPENDIX B

PRACTICE TASK LIST

Practice Objective . . . . After practicing the following tasks you will be able to:

1. Inspect the transfer case.
2. Check the operation of the sprag unit.
3. Adjust the transfer linkage.
4. Replace such parts as air vent valves, output cover gaskets, and air shift lines.

TASKS

Note. - To peform the following tasks you will need a 2-1/2-ton, 6 x 6 truck, a 5-ton, 6 x 6 truck, the -20 TM for each vehicle, and a general mechanic's toolbox.

1. Perform an inspection on the transfer case of each vehicle.
   - a. Check the oil level and check for oil leaks.
   - b. Check for loose or missing bolts.
   - c. Check the linkage condition and operation.
   - d. Check the operation of the transfer case.
2. Check the operation of the sprag unit on a 2-1/2-ton truck.
   - a. Jack up one front wheel and check the operation of the unit in forward and reverse positions.
   - b. Check for movement of the shift rod lever.
   - c. Adjust the linkage if required.

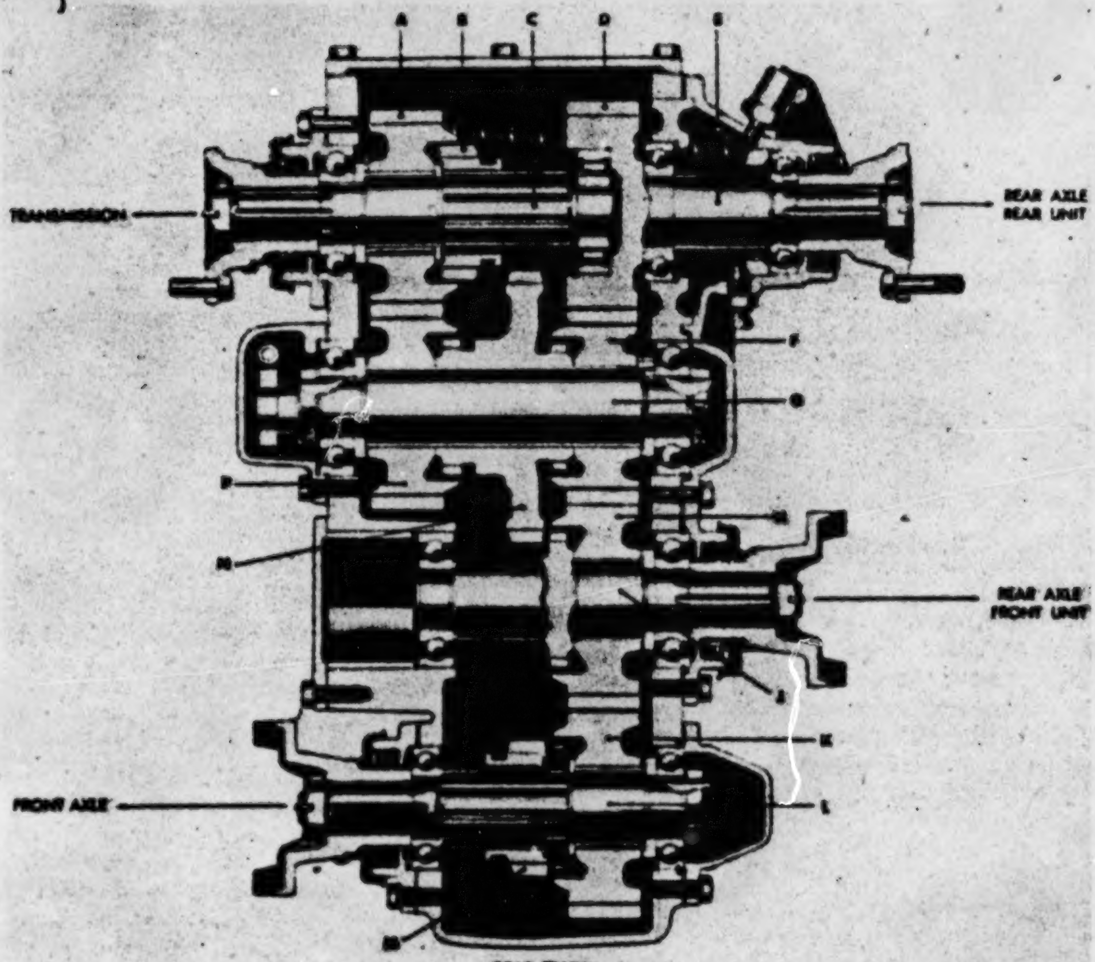
3. There are some parts the organizational wheeled vehicle mechanic must replace. Here are a few to practice removing and replacing.

   a. Transfer case air vent valve.

   b. Transfer cover output seal (gasket) on a 2-1/2-ton truck.

   c. Flexible air shift line on a 5-ton truck.

ARMY--APG, MD--15-M



GEAR TRAIN

A—MAINSHAFT CONSTANT MESH GEAR
B—MAINSHAFT SLIDING GEAR
C—MAINSHAFT
D—REAR AXLE (REAR UNIT) DRIVE GEAR
E—REAR AXLE (REAR UNIT) DRIVE GEAR ASSEMBLY
F—IDLER SHAFT CONSTANT MESH GEAR
G—IDLER SHAFT
H—DRIVE SHAFT CONSTANT MESH GEAR
J—REAR AXLE (FRONT UNIT) DRIVE SHAFT
K—IDRIVE SHAFT CONSTANT MESH GEAR
L—FRONT AXLE DRIVE SHAFT
M—DRIVE SHAFT SLIDING GEAR
N—IDLER SHAFT LOW SPEED GEAR
P—IDLER SHAFT CONSTANT MESH GEAR

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EXERCISE RESPONSE LIST

SUBCOURSE 63B205
WHEELED VEHICLE CLUTCHES, TRANSMISSIONS, AND TRANSFERS

OCTOBER 1975

DEPARTMENT OF ARMY WIDE TRAINING SUPPORT
US ARMY ORDNANCE CENTER AND SCHOOL
ABERDEEN PROVING GROUND, MARYLAND

214

ANSWER SHEET

FOR STUDENT USE ONLY - DO NOT RETURN

	a	b	c
1.	104	501	538
2.	223	667	586
3.	421	309	243
4.	241	483	527
5.	378	186	612
6.	660	110	427
7.	582	280	420
8.	630	197	483
9.	679	143	661
10.	547	665	342
11.	280	578	231
12.	635	460	235
13.	429	386	636
14.	103	112	520
15.	118	336	178
16.	610	276	482
17.	238	382	624
18.	101	490	382
19.	521	381	380
20.	628	378	426
21.	466	124	662
22.	641	482	242
23.	326	133	667
24.	283	485	637
25.	248	320	288
26.	182	285	423
27.	288	661	643
28.	673	380	432
29.	637	213	286
30.	182	284	117
31.	661	471	341
32.	279	617	324
33.	601	577	282
34.	280	679	288
35.	347	572	129
36.	186	684	278
37.	179	683	401
38.	486	684	189
39.	218	634	482
40.	467	627	386
41.	437	523	333
42.	348	638	274
43.	277	384	647
44.	538	486	680
45.	113	408	382
46.	522	387	288
47.	181	642	412
48.	308	662	283
49.	600	379	416
50.	116	483	204
51.	164	418	533
52.	629	186	520
53.	311	605	466
54.	167	239	323
55.	304	442	227
56.	631	380	580
57.	677	208	425
58.	380	402	147
59.	316	638	403
60.	184	663	288
61.	383	570	477
62.	284	387	109
63.	207	546	648
64.	422	138	508
65.	616	684	417
66.	146	467	218
67.	668	285	376
68.	621	177	683
69.	468	609	320
70.	134	467	684
71.	365	446	170
72.	200	566	307
73.	674	184	616
74.	567	280	682
75.	228	608	161
76.	372	141	668
77.	540	665	210
78.	444	229	313
79.	686	580	173
80.	100	344	631
81.	246	405	480
82.	380	440	624
83.	600	365	122
84.	223	526	339
85.	565	282	271
86.	176	684	488
87.	434	180	676
88.	651	363	184
89.	228	474	672
90.	408	138	382
91.	371	535	202
92.	513	286	446
93.	108	664	543
94.	644	282	484
95.	387	518	181
96.	188	374	608
97.	567	127	332
98.	410	618	212
99.	247	451	567
100.	328	651	188
101.	198	301	614
102.	663	131	460
103.	431	607	280
104.	281	480	512
105.	581	286	318
106.	116	667	238
107.	601	222	419
108.	414	198	686
109.	285	611	172
110.	667	438	320
111.	140	381	588
112.	384	667	183
113.	610	118	586
114.	140	447	209
115.	482	336	623
116.	330	668	404
117.	108	224	300
118.	588	684	142
119.	308	121	640
120.	183	470	273
121.	625	346	515
122.	484	285	380
123.	217	668	438
124.	334	503	139
125.	583	388	291
126.	111	660	331
127.	633	282	470
128.	216	438	528
129.	411	198	671
130.	585	189	308
131.	368	667	276
132.	144	467	656
133.	476	502	123
134.	602	288	480
135.	229	303	588
136.	168	441	305
137.	472	680	125
138.	380	187	576
139.	534	380	244
140.	675	221	401
141.	287	660	605
142.	384	685	189
143.	641	287	488
144.	163	586	385
145.	546	222	287
146.	228	440	514
147.	418	138	608
148.	505	386	198
149.	284	604	408
150.	424	188	363
151.	645	219	548
152.	128	583	284
153.	321	453	676
154.	171	384	620
155.	683	237	484
156.	435	662	148
157.	680	102	337
158.	310	532	270
159.	214	478	671
160.	678	182	348
161.	428	613	114
162.	201	552	443
163.	608	373	680
164.	180	481	[illegible]
165.	367	272	554
166.	586	386	174
167.	343	161	686
168.	120	519	405
169.	626	246	314
170.	487	662	203
171.	285	433	540
172.	618	185	381
173.	473	653	249
174.	211	686	480
175.	182	381	661
176.	308	486	588
177.	538	285	105
178.	445	187	646
179.	183	642	[illegible]
180.	234	665	[illegible]
181.	670	283	560
182.	302	430	148
183.	574	317	240
184.	186	348	684
185.	326	663	281
186.	622	176	486
187.	662	280	616
188.	208	517	327
189.	686	413	107
190.	377	673	132
191.	135	318	461
192.	683	185	370
193.	484	251	525
194.	544	469	232
195.	287	530	640
196.	668	283	485
197.	316	160	632
198.	137	511	340
199.	568	383	280
200.	478	680	128

RESPONSE NUMBER	RESPONSE*
100	CORRECT. Low oil level or loose bands could cause this.
101	Para 3d
103	CORRECT. This is one of the reasons for using this type of gear; another is, it makes a small compact unit.
104	Para 3a
106	Para 6a
109	CORRECT. Keep this valve clean and in operating condition.
110	CORRECT. All of these components are used in a planetary gear set.
112	Para 4e
113	Para 4b
115	Para 3b
116	Para 2c
117	Para 6a
118	Para 6a and 6b
119	CORRECT. For this reason, the shafts on which the gears operate are designed to prevent the gears from moving sideways.
122	Para 3d
124	CORRECT. For this reason, they are used on heavy vehicles.
127	Para 3a

*If your response is not listed CORRECT, refer to the indicated paragraph for the proper answer.

129 CORRECT. The clutch is not usually replaced at the organizational level of maintenance.

131 Para 3b

133 CORRECT. The clutch can only connect or disconnect the engine's power to the power train.

134 Para 3a

136 Para 3d

138 Para 5d

140 CORRECT. You should inspect these and replace them if they are found to be defective.

141 CORRECT. Also, the engine should be running at an idle speed when checking the transmission oil.

143 Para 10d

145 Para 11g

147 Para 7b

149 Para 5b

150 Para 4a

152 CORRECT. This is splined to and turns the clutch shaft.

154 CORRECT. It can also cause oil leaks.

156 Para 4

159 Para 3a

161 Para 10g

164 Para 4b

166 CORRECT. The torque applied to the bolt in this case would be 120 lb-ft.

167 Para 8a

170	CORRECT. This bearing only operates when the clutch is disengaged.
172	Para 4b
173	Para 6a
175	Para 4c
177	CORRECT. If torqueing them to this does not stop the leak, support maintenance will have to take care of it.
178	Para 3b
179	Para 4 and foldout
181	Para 4a
184	Para 5c
186	Para 3a
188	Para 4
190	Para 4b
191	Para 9a
192	Para 6a
193	CORRECT. This will relieve any windup.
194	Para 6 and foldout
195	CORRECT. It provides a mounting for the shafts and gears.
197	Para 9e
199	Para 3a
200	Para 5d
202	Para 5
204	Para 2c

205	Para 11b and c
206	CORRECT. By doing this, the speedometer will register correctly when the transfer is in either high- or low-range.
207	CORRECT. Grease on the facings can cause the clutch to slip or grab.
209	Para 5b
210	CORRECT. Tightening the mounting bolts may take care of this.
212	Para 3a
213	Para 5a
215	Para 4 and foldout
218	Para 11g
220	Para 5e
222	CORRECT. The lubricant is thrown or splashed to all parts of the transfer by the moving parts.
223	Para 3b
225	Para 8a
227	Para 5f
228	CORRECT. This must be kept tight to prevent wear of the key used to lock the yoke to the shaft.
231	Para 9e
233	Para 4a
235	CORRECT. Twisting force is torque and it is measured in lb-ft.
236	Para 2c
238	CORRECT. This will shift the sprag unit so the front wheels can turn in the reverse direction.

239	Para 8a
241	Para 4c
242	CORRECT. The only time this bearing is working is when the clutch is released, being released, or being engaged.
243	CORRECT. The bevel gear always has the face of the gear cut at an angle.
245	Para 6c
247	Para 3a
248	Para 2b
250	CORRECT. At this time the other sprag unit is locked out.
253	CORRECT. This gear will also carry fairly heavy loads.
256	CORRECT. This is one of the causes of incorrect clutch free travel.
259	Para 11a
260	Para 3c
262	CORRECT. This is used to lock the ring gear to the transmission housing.
264	CORRECT. This is true on most wheeled vehicles.
266	Para 7b
268	Para 6
271	Para 4b
274	CORRECT. It is supported here by a pilot bearing.
276	CORRECT. All the other components are either driven or operating members.
277	Para 11a
278	Para 4

279	Para 5b
281	Para 3b
282	Para 4b
284	Para 3b
286	Para 3b
288	CORRECT. They absorb the shock of sudden loads and the release of loads on the engine.
289	Para 9e
290	Para 9e
292	CORRECT. The clutch is located between the engine and transmission.
293	Para 2b
295	Para 3b
296	Para 4b
298	CORRECT. They should be tightened to 20-25 lb-ft.
299	Para 11a
301	Para 3a
304	CORRECT. It will only let one shifter shaft be moved at a time.
307	Para 5d
309	Para 3d
311	Para 5a
313	Para 5e
316	CORRECT. This will relieve any windup in the power train.
318	Para 3b

320	Para 4
323	CORRECT. The gears that run free on the main shaft can be connected to the shaft by this type clutch.
324	CORRECT. Remember, proper adjustment of this has a lot to do with the operation and life of the clutch.
326	Para 1
328	Para 3a
329	Para 4b
330	Para 2b
332	Para 3a
333	Para 3a
335	CORRECT. Most transfer cases have a high- and low-range and a means of engaging and disengaging the front wheel drive—but do not have a reverse range.
336	Para 3b
339	Para 4a
341	CORRECT. Not enough pedal travel can cause the clutch to not be fully engaged.
342	Para 9e
344	Para 6
347	Para 5
349	Para 3b
350	CORRECT. Some of these leaks can be taken care of by the organizational repairman, others will have to go to support maintenance.
352	Para 3d
355	Para 4b

356	CORRECT. The driving members are attached to and turn with the crankshaft.
358	Para 8c
360	Para 3e
362	Para 3d
363	Para 5c
365	Para 3d
367	Para 3b
369	CORRECT. They may also be wet-type clutches.
371	CORRECT. If the oil level is too high or too low, the transmission will not operate as it should so the tests wouldn't prove much.
372	Para 5c
374	Para 3a
375	Para 1d
376	CORRECT. This overrides the engine governor and limits engine speed to about 1,700 RPM.
378	Para 11[illegible]
379	Para 11
381	Para 5
382	Para 2c
384	Para 6a
385	Para 5b
387	CORRECT. This pump is in operation whenever the vehicle is moving.
389	Para 7b

390	Para 3a
391	Para 3b
392	Para 4b
393	Para 9c
394	Para 11a
396	Para 4a
397	Para 11a
400	CORRECT. A cone clutch could be used for this in some applications.
402	CORRECT. When tightening these they should be torqued to 37-42 lb-ft.
403	Para 8c
405	Para 6c
407	CORRECT. Fifth gear is overdrive on these vehicles. Fourth gear is direct drive.
408	CORRECT. Transmissions may use two or more of these.
409	Para 1b
410	Para 3a
412	CORRECT. These are applied before the teeth of the sliding gear and the main gear come in contact.
414	CORRECT. It is operating as it should in this position.
415	Para 4b
416	CORRECT. Larger power takeoff units may have several forward and reverse speeds.
417	Para 10d
419	Para 3c

420 CORRECT. This will happen if any two units are locked together.

421 Para 3d

422 CORRECT. In any case, it is not the job of the organizational repairman to make the required repair.

423 Para 3b

425 Para 7b

426 Para 11f

427 Para 8

429 Para 4a

431 Para 3b

432 Para 3a

434 Para 4a

437 CORRECT. It is also easily cracked or broken by a sharp blow.

439 CORRECT. The lever should be just on the verge of moving when the transmission is shifted from first to neutral.

440 Para 3e

442 Para 5f

444 CORRECT. If water gets into the transmission, the assembly must be sent to your support unit for repair.

446 Para 7b

447 CORRECT. The sprag unit would be in reverse when it should be set for going forward, and for forward when it should be in reverse.

448 Para 5b

451 CORRECT. It is also disengaged from the idler shaft low speed gear.

452	Para 2a
454	Para 3e
457	Para 2a and foldout
459	CORRECT. Its operation is much like that of a double sprag unit.
460	CORRECT. At this time, the front pump would not be delivering oil under pressure.
462	Para 1
463	Para 9e
465	Para 4 and foldout
468	CORRECT. If this seal leaks it will leak into the flywheel housing of the engine.
471	Para 5c
474	CORRECT. This is done to make the throttle linkage adjustment.
477	CORRECT. These gears will be turning any time the engine is running and the clutch is engaged.
480	Para 3b
482	Para 4
483	Para 4c
485	Para 2b
486	Para 3d
488	CORRECT. This means the governor will only operate when the vehicle is in motion.
490	CORRECT. This is one of the reasons they are not used on heavier vehicles.
491	Para 4c(1) and foldout

492 Para 4b

493 CORRECT. It is bolted to the rear of the engine and, on some vehicles, it is supported entirely by the flywheel housing.

496 CORRECT. This is one of the things that will have to be checked during your lesson on maintenance.

497 CORRECT. Transmission oil has a tendency to foam when the vehicle is in operation.

498 CORRECT. This is always true when one external tooth gear drives another external gear.

500 Para 11

501 CORRECT. This gear also tends to be noisy during operation.

504 CORRECT. If this breaks be sure and replace it with the proper type of pin.

505 Para 5a

507 Para 3b

508 Para 5d

510 Para 2a

512 CORRECT. At this time, the rear wheels would be slipping so the front wheels help drive the vehicle.

513 CORRECT. When the pin is flush with the machined surface, tighten the locknut and shift the transmission to neutral, then back into F1 high-range, and recheck.

516 CORRECT. It should also be quiet in second and fourth gear as helical gears are being used at these times.

518 Para 4a

520 Para 11a

521 Para 3b

522 CORRECT. Here the idler gear will mesh with a drive gear in the transmission.

523 Para 3a

524 CORRECT. The linkage is also an operating member.

526 CORRECT. By connecting it in this way it will deliver oil any time the engine is in operation.

527 CORRECT. The speed will be decreased—but the torque is increased.

529 Para 4e

531 Para 6

533 CORRECT. Weak springs or worn detents can be the cause of a transmission jumping out of gear.

535 Para 5

536 Para 3a

537 Para 5a

539 Para 6

541 Para 4b

543 CORRECT. The pressure should be 180 to 220 PSI. In all other positions the pressure should be 95 to 110 PSI.

545 Para 4b

547 Para 9e

549 Para 5d

551 CORRECT. While gear B is smaller than gear A, it is in mesh inside gear A so they turn as a unit.

553 CORRECT. If either of these is defective it can cause gear clash.

555 CORRECT. At this time, the thrust of the gears is such that it tends to force the gears out of mesh.

556 Para 6a and 6b

557 CORRECT. As gear B is smaller than gear N there is a gear reduction.

559 CORRECT. The test should be made with the engine running at 1,000 RPM.

561 CORRECT. They act as wedges to lock the sprag unit when front wheel drive is needed.

562 Para 9e

563 CORRECT. This is splined to the transmission main drive pinion.

565 CORRECT. Another of its purposes is to delay upshifts.

567 Para 3c

569 Para 5 and 5a

570 Para 9c

572 Para 5

573 CORRECT. The bottom of an oilcan, when pushed in, will spring back out when the pressure is released. The same is true of a diaphram spring.

575 CORRECT. Its purpose is to move oil from the reduction unit case to the oil pan sump.

577 Para 8b

578 CORRECT. We can have this only when none of the units are held or locked together.

579 Para 10d

580 Para 11b and c

581 Para 5c

582 Para 3d

584 CORRECT. It is connected from the clutch release bearing pullback spring screw to the clutch release bearing sleeve.

587 Para 3a

590 Para 2

591 Para 4b

594 CORRECT. This is moved by the clutch release bearing.

595 Para 3b

597 Para 1

600 CORRECT. The rest of the clutches are multiple disk type.

601 Para 3c

603 Para 3c

605 CORRECT. In turn, this gear drives the rear axle (rear unit) drive gear which is a part of the rear axle (rear unit) drive gear assembly.

607 Para 3b

608 Para 11g

610 CORRECT. Many replacement transfer cases are issued without this valve, which means the one from the old case will have to be used.

611 CORRECT. If the lever does not move, the rod may be adjusted improperly or it may be too short.

612 Para 1d

614 CORRECT. Also, the main shaft constant mesh gear drives the idler shaft constant mesh gear.

615 Para 10d

617 Para 5b

619 CORRECT. It is splined to the main shaft sliding gear.

621 Para 3c

623 Para 1

624 CORRECT. This is sometimes called a self-energizing type band. When the band is applied, the action of the drum aids in keeping the band from slipping.

627 Para 2a

628 CORRECT. This type works well on a light vehicle.

629 Para 11a

630 CORRECT. Either the sun gear or the ring gear can be used as the input at this time.

631 Para 2

634 CORRECT. This is one of the driving members.

635 Para 1b

636 CORRECT. This is one of the reasons for using gears.

637 CORRECT. When the clutch is engaged the driven member is clamped between the driving members and can then turn the transmission main drive pinion.

638 Para 8c

639 Para 3b

642 Para 9a

643 CORRECT. This contains the release bearing.

644 Para 3e

647 CORRECT. A part of this shaft extends to the outside of the case.

648	Para 4b
651	Para 5c
654	Para 6
657	CORRECT. This gear is not only fairly quiet, but it can also handle a heavy load.
659	Para 4b
661	CORRECT. This will also be true if the sun gear is turned and the carrier held.
662	Para 8c
665	Para 5d
667	Para 6a
669	Para 4
672	Para 8a
674	Para 5c
677	Para 7b
679	Para 11a
682	CORRECT. They should be torqued to 10-14 lb-ft.
684	Para 4c
685	CORRECT. This will be true if either of the other two members is used as the output.
687	Para 4b
688	Para 6a
690	Para 8a
691	Para 8b
693	Para 3b

232	694	Para 3a
	696	Para 5c
	699	Para 6

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US ARMY ORDNANCE CENTER AND SCHOOL
CORRESPONDENCE/OJT COURSE

EXAMINATION VERSION I

Ordnance Subcourse No 63B205	Wheeled Vehicle Clutches, Transmissions, and Transfers
Credit Hours	One
Objective	To test the students's overall knowledge of material covered in this subcourse.
Suggestions	Before starting this examination, it is suggested that you review all lessons in this subcourse.
Texts.	All Study Texts used in this subcourse.
Materials Required	None

(Do not send these pages in - use the answer sheet provided for recording and mailing your solution.)

Requirement (40 Questions)—Weight 100—All items are weighted equally.

MULTIPLE CHOICE

(See instructions on answer sheet provided)

1. Organizational maintenance personnel are normally allowed to replace the air vent valve and what other component of the transfer case on 2-1/2-ton vehicles?

   a. Sprag unit
   b. Output cover seal
   c. Rear output shaft
   d. Front output shaft seal

2. The conventional transmission usually has the power takeoff mounted on the

   a. rear.
   b. side.
   c. top.
   d. bottom.

3. Which oil pump supplies lubricating oil to the hydramatic transmission when the vehicle is not moving?

   a. Engine
   b. Front
   c. Rear
   d. Reduction

4. The movement of the conventional transmission sliding gear is controlled by the

   a. reverse idler shaft.
   b. main shaft.
   c. shifter shaft.
   d. counter shaft.

5. The cone clutch in the conventional transmission synchronizer is used to

   a. change the direction of all the gears.
   b. stop the movement of the low and reverse gears.
   c. match the speed of meshing gears.
   d. slow down the speed of the idler gears.

6. Organizational maintenance of the clutch is normally limited to

   a. pressure plate and disk replacement.
   b. release and pilot bearing repair.
   c. linkage adjustment and repair.
   d. disk refacing and replacement.

7. What is the purpose of the poppet ball and spring used in the conventional transmission control mechanism?

   a. Push the interlock in place
   b. Keep the shifter shaft setscrews tight
   c. Aline transmission top to the case
   d. Hold the shifter shaft in a selected position

8. Which condition in a planetary gear set will produce a direct drive?

   a. Sun gear held with a planet carrier input
   b. Planet carrier held with a ring gear input
   c. Ring gear and sun gear locked together
   d. No members held or locked together with a sun gear input

9. What output will result in a planetary gear set if the sun gear is turned clockwise as an input and the ring gear is held from turning?

   a. Clockwise rotation and reduction
   b. Counterclockwise rotation and overdrive
   c. Direct drive
   d. Neutral

10. What planetary gear set members must be turned, held, or locked to make the unit operate in reverse reduction?

   a. Planet carrier held, sun gear input
   b. Sun gear held, ring gear input
   c. Ring gear held, planet carrier input
   d. Planet carrier locked to sun gear

11. What component prevents the conventional transmission from shifting into two speeds at the same time?

    a. Slide rail
    b. Interlock
    c. Synchronizer
    d. Poppet ball

12. Not enough clutch pedal free travel can cause the clutch to

    a. drag.
    b. grab.
    c. chatter.
    d. slip.

13. The clutch pedal movement before the clutch starts to disengage is called the

    a. release distance.
    b. free travel.
    c. pressure start.
    d. final spin.

14. In the hydramatic transmission the unit that is driven at engine speed in all ranges is called the

    a. rear pump.
    b. planet carrier.
    c. sun gear.
    d. front pump.

15. In planetary gear systems the ring gear is sometimes referred to as the

    a. bevel gear.
    b. helical gear.
    c. internal gear.
    d. pinion gear.

16. What part of a conventional transmission is mounted in the center of the engine flywheel?

    a. Countershaft bushing
    b. Front part of the input shaft
    c. Shifter shaft guide
    d. Rear part of the input shaft

17. What is the purpose of the springs in the clutch disk?

a. To prevent uneven wear
b. To smooth out the power flow
c. To strengthen the disk
d. To reduce clutch slippage

18. What hydramatic transmission pressure test is made by moving the vehicle forward at 30 MPH in neutral with the ignition switch off?

a. Front oil pump
b. Fluid coupling
c. Reduction oil pump
d. Governor

19. Which of the following is a driven member of the clutch?

a. Pressure plate
b. Flywheel facing
c. Clutch disk
d. Release lever

20. The primary purpose of the accumulator in the hydramatic transmission is to furnish enough oil

a. to position the two apply pistons after release.
b. for proper lubrication of bands and clutches.
c. at a pressure high enough to apply the reduction unit clutches.
d. to move the double transition valve to the open position.

21. What will NOT be caused by too much pedal free travel?

a. Gear clash
b. Clutch drag
c. Clutch slippage
d. Clutch grab

22. What is a disadvantage of using spur tooth gears?

a. They cost more than other gears
b. They are harder to lubricate
c. They can only be used on angle drives
d. They transmit force on only one tooth at a time

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23. When replacing the transfer case on an M35A2 2-1/2-ton truck, the air vent valve on the defective transfer case is

a. cleaned and reused.
b. removed and discarded.
c. left on defective case.
d. sealed and painted.

24. What is used in the hydramatic transmission to lock two planetary members together?

a. Multiple disk clutch
b. Double wrapped band
c. Cone clutch
d. Single wrapped band

25. During the inspection of a vehicle you find there is too much clutch pedal free travel. What worn component could cause this condition?

a. Clutch disk
b. Pressure plate
c. Clutch linkage
d. Flywheel

26. What supplies the oil at a variable pressure to the shifter valves of the hydramatic transmission?

a. T-valve
b. Double transition valve
c. Reduction pump
d. Governor

27. Most military conventional transmission cases are made of

a. aluminum alloy.
b. forged steel.
c. cast aluminum.
d. cast iron.

28. Oil should be added to the hydramatic transmission when the engine is running and the control lever is in

a. F1 low range.
b. neutral.
c. reverse.
d. F1 high range.

29. The reverse and reduction units of the hydramatic transmission each contain a

    a. double wrapped band.
    b. cone clutch.
    c. mechanical servo.
    d. disk clutch.

30. The throttle valve lever is one hydramatic transmission component that may be

    a. bent to fit properly.
    b. replaced by the driver.
    c. installed in any position.
    d. adjusted manually or automatically.

31. The air controlled double sprag unit transfer is used on the

    a. 1/4-ton truck.
    b. 3/4-ton truck.
    c. 2-1/2-ton truck.
    d. 5-ton truck.

32. The purpose of an idler gear is to

    a. change torque and speed.
    b. reduce vibration.
    c. allow for a neutral position.
    d. change direction of rotation.

33. By what method of lubrication is the transfer case without a power takeoff lubricated?

    a. Force or splash
    b. Force
    c. Full force
    d. Dip or splash

34. Which is a major cause of the hydramatic transmission shifting too fast or too slow?

    a. Bands too tight
    b. Clutches worn
    c. Governor weights worn
    d. Transmission too full of oil

35. If the conventional transmission input shaft bearing retainer oil seal is leaking it will cause damage to the

    a. starter motor.
    b. input shaft.
    c. clutch.
    d. release bearing.

36 What causes the most problems for the organization repairman on the M151 truck transmission?

    a. Loose mounting bolts
    b. Worn bearings
    c. Driver abuse
    d. Lubricant leakage

37. If the detent balls and springs of a shifting mechanism are worn it will cause the transmission to

    a. slip out of gear.
    b. make unusual noises.
    c. shift hard.
    d. leak oil.

38. In the M151 truck, which transmission oil seal cannot be inspected with the powerplant in the vehicle?

    a. Parking brake drum
    b. Rear output shaft
    c. Front output shaft
    d. Input shaft

39. Which clutch will be slower to engage?

    a. Wet plate
    b. Wet multiple disk
    c. Dry single plate
    d. Dry multiple plate

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40. **Which statement is true in regards to types of gears?**

- a. **Two helical gears in mesh try to slide in opposite directions on their shafts**
- b. **Spur gears are stronger than most other types of gears due to their tooth design**
- c. **Herringbone gears are actually two spur-type gears mounted side by side**
- d. **Conventional transmissions use bevel gears in the first and second speed ranges**